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JOHN HENRY JENSEN

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SCIENCE EDUCATION

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JOHN HENRY JENSEN

To one of the pioneers in the field of science education is made the Eighteenth Science Education Recognition Award. A son of Norwegian parents, Professor Jensen has taught science in the north central United States where so many Scandinavians settled after coming to this country.

John Henry Jensen was born in Pullman, Illinois, July 1, 1883. His father Hans Jensen, born in Bremnes, Norway, came to the United States in 1880. Having learned the cabinet making trade at Haugesand, he worked for the next forty-six years in the Pullman Palace Shops at Pullman, Illinois and Buffalo, New York. He served as a foreman at the Buffalo plant for twenty-six years. The Mother, Johanna T. Tollefson, came to the United States in 1881 from Sven, Norway. Professor Jensen has four sisters, three of whom taught school: Ellen (Mrs. Robert Anderson), Clara (Mrs. Harold P. Glaser), and Florence (Mrs. J. N. Riggs). A sister Jennie lives in Buffalo, New York as does Clara. Florence lives in Orlando, Florida.

Professor Jensen married Ruth Hanaford at Aurora, Illinois, July 1, 1914. Mrs. Jensen taught Biology and English at Mora, Minnesota, two years and Biology, Mathematics, and English at Aurora College, 1912–14. She has an A.B. degree from the University of Minnesota. The Jensens have the following children: Dr. John Henry Jensen, Jr. of Kingsport, Tennessee (Research Division, Tennessee Eastman Kodak Company). Elizabeth (Mrs. Merlyn Herrick of Bloomington, Indiana. Mr. Herrick is Motion Picture Production Supervisor for the Audio-Visual Center of Indiana University.); Ruth Clara (Mrs. Thomas Loverude)—an elementary grade school teacher; Richard of Cody, Wyoming (Music specialist and Director); Lucille (Mrs. Robert DeLap) of Midland, Michigan, an elementary grade school teacher; and Robert of Midland, Michigan (Research chemist with the Dow Chemical Company). There are fifteen grandchildren: Elizabeth (David, Eileen, and Bruce); Ruth Clara Russell, Marilyn, John, Nancy, and Douglas); Richard (Richard, Jr., and Elizabeth); Lucille (Amy, Robert, Jr., Patricia, Ronald, and Elizabeth Ann).

The Jensens are members of the Methodist Church.

Professor Jensen graduated from the Masten Park High School Buffalo, New York, in 1904. He worked for three years in the plumbing and cabinet shop of the Pullman Palace Car Company at Buffalo. He enrolled in the University of Michigan in 1907 and received A.B. and M.S. degrees from there in 1911 and 1916. He attended summer schools at the University of Minnesota in 1915 and Teachers College, Columbia University, 1922 and 1925. Teaching experiences includes: teaching physics and chemistry at Aurora College, Aurora, Illinois, 1912–16; physics at Central High School, Lansing, Michigan, 1916–18. Northern Normal and Industrial College (now Northern State Teachers College), Aberdeen, South Dakota, 1918–1953. From 1918–22, he was Professor of Physics and Chemistry; 1922–27, Head of the Division

of Science and Professor of Chemistry; 1928–32 Head of the Division of Science and Professor of Chemistry and General Science; 1932–39, Head of the Division of Physical Science and Professor of Chemistry; 1939–53, Chairman of the Division of Science and Mathematics and Professor of Chemistry. Since 1953, Professor Jensen has continued on a part-time teaching basis. He has taught General Chemistry, Organic Chemistry, Quantitative Analysis, Biochemistry, Physical Science, and Physical Science for the Elementary Grades. During 1943–44 he taught Chemistry in the Army Specialized Training Program.

Professor Jensen is listed in *American Men of Science, American Men of Science—Physical Science Division, Leaders in American Science, Leaders in Education, Who's Who in the Midwest,* and *American Educators of Norwegian Origin.* Membership in organizations include National Education Association, American Association for the Advancement of Science (Fellow), American Institute of Chemists (Fellow), National Association for Research in Science Teaching (Life), South Dakota Education Association (Life), American Chemical Society, South Dakota Academy of Science, National Retired Teachers Association (Life), the Beadle Club (members elected on basis of having given meritorious service to the cause of public education in the state of South Dakota over a decade), and the National Science Teachers Association, (State Director since the organization of N.S.T.A.). He has served as Vice-President of the South Dakota Academy of Science and Chairman, Science Division, Department of Curriculum Revision for the State Education Department of South Dakota. He also served as Chairman of the Division of Chemistry on Committee on Minimum Equipment for Teaching Chemistry.

At Northern State Teachers College Professor Jensen has Conducted ten summer institutes for science teachers, served on numerous science committees (local, regional, state, and national)—(often as chairman); on panels and round-tables. He conducted four science surveys of the state of South Dakota. He was state chairman for five years of the American Chemical Society Garvin Prize Essay Contest. He is an evaluator for the National Science Teachers Association package service.

Publications include:

"High School Science Survey of South Dakota," *Journal of Chemical Education,* 4:897–904, 1927; co-author with Earl R. Glenn, "An Investigation of Types of Classrooms for Chemistry and Other Science in the Small High Schools," *Journal of Chemical Education,* 6:634–664, 1929; "Aids for the Teaching of Science," *School Science and Mathematics,* 29:March and April; "Minimum Equipment for High School Chemistry," *Journal of Chemical Education,* 14: August, 1937. "Report on Minimum Equipment for High School Chemistry." *Journal of Chemical Education,* 5:749–754, June 1928. "A Basis for the Critical Evaluation of the Present Programs in Senior High School Science," Monograph 1935, Proceedings of Department of Science Education of N.E.A., P. 103–115. *Science for Secondary Schools,* Study Bulletin No. 17, 1936, Department of Public Instruction, South Dakota Education Association, 852 pages. (Detailed biology and general science units, physics and chemistry outline units—designed for less experienced teachers in small high schools.)

Professor Jensen has actively and continuously worked to improve science teaching in the state of South Dakota ever since going to Northern State Teachers College in 1918. This has involved not only improving the science and educational backgrounds of the science teachers but also in upgrading the all-too-often meager science equipment in the high schools, especially the small high schools which so characterize the state of South Dakota. Apathy, frustration, discouragement often have been the fruits of the moment. It takes courage, determination, a high sense of personal responsibility and devotion, to carry on through the years as Professor Jensen has done. But his love of teaching, a personal interest in every student, and in each science teacher have been the incentives to help Professor Jensen carry on a difficult task in a pioneer state to the end that the accomplishments loom large in 1959 as he

looks back to 1918. Professor Jensen notes he started out at a salary of seventy-five dollars a month at Aurora College and during the depression days of the thirties salaries were again at a very low ebb.

Professor Jensen leads as active a life now as he did before retirement—possibly even more so at present. He has been doing part-time teaching since retirement in 1953. For many years, dating back to prohibition days he did state service in making alcoholic analysis in cases involved in driving an automobile while under the influence of alcohol. At present he still does this work for the local Aberdeen police. He also is very active in the National Retired Teachers Association, as State Director of the National Science Teachers Association, and in the science, and regional meetings of the South Dakota Education Association. He and his wife reside at 802 Eighth Avenue, S.E., Aberdeen, South Dakota. To John Henry Jensen, a science education pioneer, who despite many difficulties, heart-breaking frustrations, and always meager financial rewards, maintained the highest personal and professional standards, and in the end saw his unremitting efforts crowned with success, goes the Eighteenth Science Education Recognition Award.

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AN EVALUATION OF THE INTRODUCTORY PHYSICS COURSE ON FILM *

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AND

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INTRODUCTION

DURING the 1956–57 school year, Encyclopedia Britannica Films Inc., produced on film a series of 162 lectures and demonstrations conducted by Professor Harvey E. White, Stanford University. The Bureau of Visual Instruction of the University of Kansas purchased a set of these films for use by Kansas high schools.

Prior to the beginning of the 1958–59 school year, two large high schools within the same school district in an Eastern Kansas suburban county in the greater Kansas City area indicated a willingness to participate in an evaluation of the introductory physics course on film.

One of the schools, with nine physics classes and two teachers served as the experimental group. The nine classes contained 225 students, and the class size varied from 21 to 30 with a median of 25. The second school, with seven physics classes and two teachers, served as the control group. The seven classes contained 176 students and the class size varied from 21 to 32 with a median of 26.

These schools were selected for several reasons. The schools are similar in size, purpose, and community background. By use of single large schools it was possible to obtain samples sufficiently large enough to allow statistical analysis, yet homogeneous enough to minimize the effect of such variables as differences in school size, purpose, teacher enthusiasm, and community background. It was felt that the use of a great number of smaller schools would have introduced a number of uncontrollable variables which would have reduced the significance of the study.

THE PROBLEM

The problem was one of testing which method produced superior results in measured achievement during the period of one school year of instruction: the conventional method or the film method of instruction. The design adopted required that differences which might occur in performance of the two groups were to be tested for significance by assumption of the null hypothesis.

TESTS USED IN THE STUDY

In order to secure necessary data as a basis for a statistical test of the null hypothesis, it was decided to administer three tests as follows:

1. The *Dunning Physics Test, Form Am,*[1] as a pre-test at the beginning of the school year, 1958–59.
2. The *Dunning Physics Test, Form Bm,*[1] as a post-test at the end of the school year, 1958–59.
3. The *Terman-McNemar Test of Mental Ability, Form C,*[1] as an intelligence test during the middle of the school year, 1958–59.

STATISTICAL ANALYSIS OF THE DATA

One of the assumptions underlying the use of many statistical techniques, and the

* With the assistance of Goulding W. Sanderson and Chester B. Whitney, Graduate Assistants in the School of Education, University of Kansas, Lawrence, Kansas, and W. W. Strong, High School Physics Instructor in the Experimental School.

[1] Published by the World Book Company, Yonkers-on-Hudson, New York.

technique of analysis of variance and covariance, which are used in this study is reasonable normality of test data. The scores obtained by administering the three tests to the entire population in this study, were tabulated into frequency distributions and plotted on normal probability paper. All three lines were approximately straight indicating normality of test data on all three tests.

ANALYSIS I

Did the Experimental Classes Achieve Significantly More than the Control Classes with Intelligence Quotients and Pre-Test Scores Held Constant?

Before the test data in each treatment group could be pooled, the assumptions basic to pooling on the end-test had to be satisfied, namely: (1) homogeneity of variances, and (2) homogeneity of means. The assumptions were tested for all of the classes within each treatment group. The first assumption was tested by using the Bartlett test on the "sum of squares within groups," and the second assumption was tested by using the F-test, in which F was found by dividing the mean square between groups by the mean square within groups.

In the case of the experimental group, the Bartlett test yielded a chi-square value of 2.57 with 8 degrees of freedom. The F-test yielded a value of 0.99 with 8 and 216 degrees of freedom. Neither of these values was significant at the 5 per cent level. Thus it was possible to pool the nine classes in the experimental school into one group for purposes of comparison with the control group. The seven classes in the control group yielded a chi-square value with the Bartlett test of 3.99 with 6 degrees of freedom. The F-test yielded a value of 0.41 with 6 and 169 degrees of freedom. Neither value was significant at the 5 per cent level. Thus, it was possible to pool the seven classes in the control school into one group for purposes of comparison with the experimental group.

The assumptions which had to be met before the final step could be applied were: (1) homogeneity of variances using the end-test scores for the two pooled groups, and (2) homogeneity of regression within groups for the two pooled groups. These assumptions were tested by the Bartlett test. Chi-square values of *5.94* and *3.11* were obtained in each instance. These values were not significant at the five per cent level.

One final step was now in order, namely, the calculation of the F ratio using the adjusted sums of squares. The results are shown in Table I.

Thus, the null hypothesis was accepted and it was concluded that no difference in achievement existed between the two groups holding intelligence quotients and pre-test scores constant. The adjusted means for the two groups were: experimental—41.61 and control—40.69.

ANALYSIS II *

Did the Students of the Experimental

* The material presented in this analysis was obtained from the following source: Chester B. Whitney. "An Analysis of the Relative Effectiveness of the Harvey E. White Physics Films at Different Intelligence Levels." Unpublished Master of Science in Education Thesis, University of Kansas, 1959. 63 pages.

TABLE I

ANALYSIS OF VARIANCE AND COVARIANCE WITH INTELLIGENCE QUOTIENTS AND PRE-TEST SCORES HELD CONSTANT

Source of Variation	d.f.	SS	MS	F
Within groups	397	21612.52	54.44	
Between groups	1	81.64	81.64	1.50*
Total	398	21694.16		

* Not significant.

Classes with Above Average, Average, and Below Average Intelligence Quotients Achieve Significantly More Than Their Counterparts in the Control Classes?

Since a comparison of the two groups in Analysis I did not yield significant results, attempts were made to locate significant results by other methods.

One such attempt was made by dividing each of the two treatment groups into three sub-groups according to intelligence quotients as follows:

1. Students with intelligence quotients above 124.
2. Students with intelligence quotients between 113 and 124.
3. Students with intelligence quotients below 113.

Selection of intelligence quotients of 113 and 124 was made because these values marked the thirty-third and sixty-sixth centiles of the intelligence quotients for all students in the study. The intelligence quotients for the entire group ranged from about 80 to about 154.

The division of each treatment group into three sub-groups according to intelligence quotients necessitated testing the assumptions basic to pooling as described in Analysis I. These assumptions were met in the case of each intelligence sub-group for each of the treatment groups.

Did the intelligence sub-groups for each treatment differ in intelligence? No statistical test was run to determine the existence of significant differences since the mean intelligence quotients were about identical in the three instances.

Thus, it was possible to compare the achievement of the students in the experimental group with the achievement of the students in the control group for each intelligence sub-group, holding pre-test scores constant. The assumptions basic to analysis of variance and covariance were met for each of the three comparisons. The results of the final step in analysis of variance and covariance are indicated in Table II, III, and IV.

On the basis of the results in Tables II, III, and IV, the null hypotheses were accepted and it was concluded that the students with above average, average, and below average intelligence quotients of the experimental classes did not achieve significantly more than their counterparts in the control classes.

TABLE II

ANALYSIS OF VARIANCE AND COVARIANCE WITH PRE-TEST SCORES HELD CONSTANT FOR STUDENTS WITH INTELLIGENCE QUOTIENTS ABOVE 124

Source of Variation	d.f.	SS	MS	F	P
Within groups	133	8056.74	60.58		
Between groups	1	22.36	22.36	<1	>.05
Total	134	8079.10			

Adjusted means: Experimental group—49.15
Control group—49.96

TABLE III

ANALYSIS OF VARIANCE AND COVARIANCE WITH PRE-TEST SCORES HELD CONSTANT FOR STUDENTS WITH INTELLIGENCE QUOTIENTS BETWEEN 113 AND 124

Source of Variation	d.f.	SS	MS	F	P
Within groups	130	8086.05	62.20		
Between groups	1	58.62	58.62	<1	>.05
Total	131	8144.67			

Adjusted means: Experimental group—40.95
Control group—39.99

TABLE IV

ANALYSIS OF VARIANCE AND COVARIANCE WITH PRE-TEST SCORES HELD CONSTANT FOR STUDENTS WITH INTELLIGENCE QUOTIENTS BELOW 113

Source of Variation	d.f.	SS	MS	F	P
Within groups	127	6653.64	52.39		
Between groups	1	37.21	37.21	<1	>.05
Total	128	6690.85			

Adjusted means: Experimental group—34.02
Control group—32.89

ANALYSIS III

Did the Students in the Experimental Classes Evidence a Significantly Greater Change in Variance from the Pre- to the Post-Test than Did the Students in the Control Classes?

An interesting area of speculation in the interpretation of an experimental study is suggested by Lucow who said: "It is here suggested as a postulate in educational philosophy that greater variation in classroom achievement is evidence of the release of individual differences among pupils during the learning process." [2] Lucow went on to say: "A change in variance from pretest to after-test was considered to be of greater import than the change in means, under the assumption that greater variance in a group indicated greater expression of individual differences."

Which of the two methods as used in this study produced the greatest change in variance from the pre-test to the post-test? The procedure suggested by Lucow and illustrated by Anderson [3] and others was used.

Since the nine classes of the experimental group and the seven classes of the control group were homogeneous with respect to variances on the post-test, the data for each group on the pre- and post-test were combined and an over-all test of significance of the increase in variance from pre- to post-test was run for each group. The results appear in Table V. Although the experimental group had the largest variance ratio, both variance ratios were significant and no statement in favor of the experimental group can be made.

Before the results in Table V may be considered conclusive, one must ask the question: Were the groups being compared significantly different in intelligence? No test of significance was run since the mean I.Q.'s of the experimental and control groups were almost identical. In addition, the increase in variance from pre- to post-test would not have much meaning unless the mean gain from pre- to post-test was significantly different from zero. The mean gain from pre- to post-test was significant

[2] William Harrison Lucow, "The Use of Analysis of Variance in Estimating the Components of Variation in An Experimental Study of Learning," Doctoral Dissertation, University of Minnesota, 1953, pp. 120–121. (A Summary of Lucow's thesis appeared in the March, 1954 issue of the *Journal of Experimental Education* (pages 265–271) and describes the statistical method used in Analysis III of this study.

[3] Kenneth E. Anderson, Fred S. Montgomery, Herbert A. Smith, and Dorothy Smith Anderson, "Toward a More Effective Use of Sound Motion Pictures in High School Biology," *Science Education,* 40 (February, 1956) 43–54.

TABLE V

TEST OF SIGNIFICANCE OF THE INCREASE FROM PRE- TO POST-TEST VARIANCE

Groups	Variance Pre-Test	Variance Post-Test	Ratio	t	d.f.
Experimental	80.28	135.32	1.69	5.82*	223
Control	117.54	164.94	1.40	3.18*	174

* Significant at the 1 per cent level.

for each group at the 1 per cent level. The mean gain for the experimental group was 14.9 raw score points and 15.3 raw score points for the control group.

Since the experimental group had a larger variance ratio than the control group, were not more of the variance ratios significant for the separate classes in the experimental group than for the control group classes? Tables VI and VII give the essential data for these comparisons. None of the t values for the control classes were significant but four of the nine t ratios for the experimental classes were significant at the 5 per cent level. In fact, two were significant at the 2 per cent level and one was significant at the 1 per cent level. It is not probable that obtaining four significant results out of nine was due to chance alone. [4]

TABLE VI

TEST OF SIGNIFICANCE OF THE INCREASE FROM PRE- TO POST-TEST VARIANCE FOR EACH EXPERIMENTAL CLASS

Class	Variance Pre-Test	Variance Post-Test	Variance Ratio	t Ratio	d.f.
1	68.17	129.30	1.90	1.87	22
2	124.84	162.64	1.30	1.11	24
3	70.27	135.58	1.93	2.07*	23
4	80.07	146.43	1.83	2.53†	22
5	75.32	123.32	1.64	1.66	24
6	71.27	150.91	2.12	3.07‡	23
7	83.75	148.11	1.77	2.62†	28
8	78.67	121.90	1.55	1.70	22
9	70.66	88.99	1.26	0.70	19

* Significant at the 5 per cent level.
† Significant at the 2 per cent level.
‡ Significant at the 1 per cent level.

TABLE VII

TEST OF SIGNIFICANCE OF THE INCREASE FROM PRE- TO POST-TEST VARIANCE FOR EACH CONTROL CLASS

Class	Variance Pre-Test	Variance Post-Test	Variance Ratio	t Ratio*	Degrees of Freedom
1	133.66	182.73	1.37	0.82	22
2	99.51	140.43	1.41	1.45	21
3	138.59	195.95	1.41	1.32	19
4	109.15	126.31	1.46	0.60	25
5	130.79	209.66	1.60	1.66	19
6	136.49	215.60	1.58	1.74	24
7	89.61	129.21	1.44	1.49	30

* None of the t ratios were significant.

In addition, the mean gain from pre- to post-test was significantly different from zero at the 1 per cent level for each of the four groups. *Thus one must conclude that the film method produced somewhat superior results than the conventional method of teaching physics.*

Was there a significant increase from pre-test to post-test variance for each of the three intelligence sub-groups described in Analysis II? The essential data is recorded in Tables VIII and IX. The intelligence sub-groups for each treatment did not differ in intelligence. Also the mean gain from pre- to post-test was significant at the 1 per cent level for each intelligence sub-group for each treatment.

Thus, on the basis of the results in Tables

[4] James M. Sakoda, Burton H. Cohen, and Geoffrey Beall, "Test of Significance for a Series of Statistical Tests," *Psychological Bulletin*, 51 (March, 1954) 172–175.

VIII and IX, *one must conclude that the film method was superior to the conventional method of teaching physics for those students in the I.Q. ranges 113–124 and 113 and below, but not superior for those in the I.Q. range 124 and above.* It is possible that the test had too low a ceiling for this top group.

TABLE VIII

Test of Significance of the Increase from Pre- to Post-Test Variance for Each of the Three Experimental Intelligence Sub-Groups

I.Q. Group	Variance Pre-Test	Variance Post-Test	Variance Ratio	t Ratio	d.f.
124 and above	83.42	110.31	1.32	1.54	65
113–124	51.10	85.39	1.67	2.75*	73
Below 113	64.51	105.31	1.63	3.14*	81

* Significant at the 1 per cent level.

TABLE IX

Test of Significance of the Increase from Pre- to Post-Test Variance for Each of the Three Control Intelligence Sub-Groups

I.Q. Group	Variance Pre-Test	Variance Post-Test	Variance Ratio	t Ratio *	d.f.
124 and above	144.99	133.01	0.92	−0.52	67
113–124	59.01	92.33	1.56	1.95	56
Below 113	76.04	74.51	0.98	−0.09	45

* None of the t ratios were significant.

INSTRUCTORS' REPORT—METHODOLOGY

The control classes devoted two days a week to lecture, discussion, and demonstration. Two days a week were devoted to laboratory experiments performed alone or in pairs. One day a week was devoted to testing and a discussion of the tests. *Modern Physics* by Dull, Metcalfe, and Brook was used as the text as well as the *Physics Workbook* by Dull, Metcalfe, and Williams. Both publications were produced by Henry Holt and Company in 1955.

The experimental classes used the same textbook and workbook. A typical film day was conducted as follows:

1. Class roll, briefing on the film, and assignment—5 to 7 minutes.
2. Film—27 to 30 minutes.
3. Class discussion—15 to 20 minutes.

Students were urged to keep a notebook on the films and to write up the laboratory experiments conducted on film as follows:

1. Clear statement of purpose.
2. Statement of the principles involved.
3. Personal evaluation of the film.
4. Statement of conclusions.

All films were previewed by the instructors and students were invited to attend these previews. Assignments in the text and workbook paralleled the films. Short objective tests were given twice a week and the questions were based on: (1) the film-guide manuals, (2) the workbook, and (3) the teacher's file of questions. Twice each six weeks, 45 minute objective tests were given.

EVALUATION OF THE FILMS BY THE INSTRUCTOR

The experimental classes viewed 149 of the 162 films. The teachers rated the films on a five-point scale and the results appear below:

Excellent	10
Very good	22
Good	85
Fair	30
Poor	2

If the ratings of the teachers are fair and

sound, it would seem that the better procedure would be a choice of films appropriate to the group of students being taught.

A few pertinent quotations are in order from one instructor's report on the project and they are as follows:

First Six-Weeks Period. The films were generally good but the newness was wearing off and some students were restless. Some would make quite a point if a mistake in calculation or some piece of apparatus were dropped as depicted on the film. Some students wanted more discussion of tests and film material. This was impossible in our limited time schedule.

Second Six-Weeks Period. Some new problems were appearing. In the afternoon classes several students used the period for sleeping. Some students complained that the room was too dark for note taking. When the blinds were adjusted to admit more light, other students could not see the picture clearly. Students had been permitted to sit wherever they saw fit. However, some students wearing glasses were troubled with glare if they sat in certain portions of the room so they were seated in places correcting this problem. Several sleepy students complained of not being able to hear. The volume was turned up and the students near the "speaker" complained that it was too loud. This necessitated some seating adjustments. Several students voiced the opinion that the time was too short and that the "tempo" was too fast.

Several students who had studied physics the previous year had come in to preview the films. They were enthusiastic about the films.

Fifth Six-Weeks Period. It was felt that interest was lagging and that some students were merely copying the laboratory results from the film. Therefore, it was announced that beginning this six-weeks period, the experimental write-up would be handed in at the beginning of the following day's class period. It was found that some students were trying to take notes by writing down everything given on the film. They would fall behind and then quit. Considerable time was spent in trying to help students realize that they could jot down the high spots and then fill in the details at a later date. It was found that many students either did not have time or would not take time to complete the notes.

The time schedule was so close and rigid in our schedule that one was constantly striving to get every part of the program to function as planned. One did not have the opportunity to interject his personality or technique into the class, to add new zest, or break the monotony. The films required a previewing, a study of the teacher's manual and constant secretarial work for the outlines and tests. One has the feeling of "losing" the class and, due to lack of time, the inability to do much about it.

Students were somewhat confused by assignments that skipped around in the text and in many cases seemed to expect the films to furnish all needed material for the class. Very little time was devoted to problems and problem solving and many students seemed to do little or no thinking on their own. It was our opinion that the teacher did not have the opportunity to establish rapport with students or secure the usual satisfaction from teaching this subject.

On the credit side, using the films makes it mandatory to keep on schedule, therefore more material is covered. Every student in the class has the opportunity to see every part of each experiment. The experiment is finished in the allotted time. Equipment is used and the results shown on the films which would be impossible in most of our class rooms. There is no problem of getting out and setting up equipment for the experiment, no breakage and no failure of equipment to function. Students see only the proper methods of taking and recording of data and computing results. The film's method of using graphs to picture and explain results is unsurpassed. If students will observe closely and study the text, it certainly gives an excellent chance to learn physics.

The teachers recommended the following:

Select the films and use about one a week to clarify difficult parts, principles, and theories. Have film experiments only for those experiments where equipment or time is lacking. If possible, lengthen the class periods so that a full thirty to forty-five minutes of class time could be devoted to class discussion, working of problems, and testing in conjunction with use of the films. In some instances the films could be edited and condensed to fifteen minutes in length.

One of the teachers has given the *Cooperative Physics Achievement Test* annually since 1952–53 except for 1954–55. The percentage of students above the median for each year were as follows:

1952–53	63.80 per cent
1953–54	63.83 per cent
1955–56	64.28 per cent
1956–57	76.00 per cent
1957–58	63.35 per cent
1958–59	65.19 per cent

Thus, it would appear that the classes of this teacher did as well as if not somewhat better, than the classes of other years except for that of 1956–57.

STUDENT OPINION

The students in the experimental classes were asked to give their opinions of the

lectures. The following is from the teachers' report:

About 240 students graciously responded to the request. Since no questionnaire was made up for them to check, the answers varied as the number of students. Forty-seven were emphatic in their praise of the method and the films. Forty-five were just as emphatic in their dislike of the films and the method. The remaining 148 liked part and disliked part, but the likes and dislikes varied so widely that an enumeration was not considered worthwhile. Among the strong points mentioned were the following:

Thirty-seven thought the experiments on the films were excellent. Twenty-five emphatically stated that they liked the laboratory experiments on film because all could see and know what was happening as well as completing the experiment in the allotted time. Twenty-five thought the films and method were a challenge. Twenty-five thought the films covered more material more effectively. Twenty suggested that the films and method were excellent for the brighter students.

Some of the weaknesses pointed out were the following:

Ninety-nine said there should be more time for a general class discussion. Fifty-two thought the teacher was not used effectively and that the films produced poor student-teacher relations. One hundred and five students thought the films promoted lack of attention and hindered effective teaching. Seventy-six stated that there should be more student-performed experiments and class demonstrations. Eighty-one students stated there were too many films and twenty specifically mentioned too many on mechanics. Fifty-two students said they had the feeling of being continually pushed for time and that the films were too long. Fifty said that the films got very boring. Fifty-five said they never had time to ask questions and the class moved so fast that they were lost much of the time.

Thirty-seven said the text and the films did not parallel each other and in some cases flatly contradicted each other. Twenty-two said the films went too fast; they could not take notes and keep up. Fifteen students did not like the darkened room and some thought it hard on the eyes to take notes. Thirty-two students stated that by the time they got an opportunity to ask a question, they had either forgotten the question or had lost the thought and were unable to ask about what they did not understand.

Some suggestions for improvement made by students were the following:

Thirty-seven students suggested using a text which would parallel the films. Many suggested Dr. White's text. Twenty-one suggested that a mineographed outline of the film material be given to each student before the film is viewed by the class. Fifty-seven suggested shorter films or longer class periods. Eighty-one suggested fewer films. Some said once a week and most all said not more than two per week. Twenty specifically mentioned cutting out part of those on mechanics. Others suggested having more class discussions, more experiments performed by students, and more class demonstrations. Many students said that to them physics meant going to class—a short hurried test—a film—a question or two and out you go.

SUMMARY AND LIMITATIONS OF THE STUDY

The data presented in this study would lead one to conclude that the film method produced somewhat greater variability in achievement than did the conventional method. Therefore, in proportion as this is true, the film method was superior. Also, it seemed to produce greater variability than the conventional method for students in the I.Q. ranges 113–124 and 113 and below. Thus, one may conclude that the film method was superior to the conventional method for those groups of students.

The limited conclusions stated above are bolstered by the fact that the two teachers in the control school had earned *considerably* more semester hours in *college physics* and *mathematics,* than had the two teachers in the experimental school. All four teachers were eligible to teach physics and all four teachers would be considered *exceptionally* well prepared in terms of total semester hours of college science earned. The average number of semester hours of college science earned for the four teachers was 70. No attempt was made to appraise the teaching effectiveness of the four teachers in the two schools. However, the school district in which the schools were located has a reputation for employing excellent teachers and each teacher must obtain a master's degree within a definite period of time.

The reactions of the teachers and the students would seem to indicate that there were too many films and that it would be a better procedure to select and show films once or

twice a week. The films selected should be those for which equipment is not available and those that demonstrate principles and theories difficult to present in a typical high school classroom.

The conclusions of this study must be tempered by the fact that only the classes in two large selected schools were used. However, the use of two schools similar in size, purpose, and community background would tend to minimize the effect of these variables. No attempt was made to secure a random sample of physics classes in the State of Kansas since the cost of a set of films and distribution of the films to a large number of schools would have been difficult.

The results of this study parallel quite closely the results as obtained in the *Wisconsin Physics Film Evaluation Project* in which 30 control and 30 experimental schools were selected at random. The general statements as reported in the *Progress Report* of May 8, 1958 read as follows:

> Stated briefly, the test results revealed that students who learned physics through the use of the supplementary Harvey White physics films attained a level of accomplishment not significantly below that attained by students who studied physics through traditional classroom techniques.
>
> There was a small but statistically significant difference in the general intelligence level of the control and experimental groups in favor of the control schools. The possible effect of this difference was analyzed through the use of analysis of covariance statistics, and it was further found that no significant difference exists between the scores earned on Unit Tests 1, 2, and 3 by the traditional instruction and film-use groups, and that no significant difference exists between the Semester Final Test scores earned by traditional instruction and film-use groups.
>
> In the analysis of covariance of the final-test scores, we found the classification by high intelligence physics class groups vs. low intelligence physics class groups to be significantly in favor of the *low*-intelligence group, adjusted means being 32.7 for the low group and 27.2 for the high-intelligence group.
>
> No other comparison in the analysis of covariance was significant, though the analysis of "teacher preparation" did suggest that students of the low preparation control and experimental group teachers had achievement inferior to that of the average and high control and experimental group teachers.

The reactions of the teachers and students to using films in physics teaching in the Wisconsin project were not unlike those made by the participants in this study. It would seem from reading the results of the Wisconsin project and this study, that much is to be gained by using the films in high school physics classes. It would also seem that there are many deterrents to the use of these films. Perhaps the happy solution to the whole problem is a wise selection of films by the teacher in terms of: (1) his preparation to teach physics, (2) the equipment and facilities available, and (3) the ability of his students to master the level of physics he is able to present.

"CONTINENTAL CLASSROOM" AND THE SMALL SCIENCE DEPARTMENT

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THE purposes of this paper are (1) to present a brief description of the Nationally televised physics course that was conceived, organized and presented by the American Association of Colleges for Teacher Education in conjunction with Dr. Harvey E. White, Professor of Physics at the University of California, and The National Broadcasting Company in 1958, (2) to focus attention on some of the major instructional problems in the teaching of physics in small institutions, (3) to examine the apparent reaction of most small science departments in high schools and colleges to "Continental Classroom," and (4) to

suggest some ways by which more science teachers may be brought into the program.

THE ORGANIZATION AND PURPOSES OF "CONTINENTAL CLASSROOM"

During the early part of the summer of 1958, The American Association of Colleges for Teacher Education sent a communication to its member and affiliated institutions announcing a very bold and revoluntionary proposal for helping to improve and upgrade science teaching in American schools. A very important aspect of that communication was an announcement concerning a group of regional conferences which were to be held in the early fall for the purpose of orienting representatives of interested institutions of the purposes and special features of the proposed program. The institutions were strongly urged to send representatives to the regional conferences, since the conferences were the principal sources of the early information concerning the proposal.

The writer is not aware of the extent to which most of the regional conferences were attended, but can authentically report that the conference in one region comprising a large number of small institutions with small science departments, some without trained physicists on their staffs, was not well attended.

After the completion of the many mechanical features of the program, such as getting the principal teacher, putting together the television staff, setting up the time schedule and soliciting the sponsors, "Continental Classroom" went on the air over the facilities of The National Broadcasting Company and 149 of its affiliated stations around the nation on October 6, 1958 at 6:30 A.M. local time.

For 1958–59, "Continental Classroom" featured a modernized physics course called "Physics for the Atomic Age." The course was purportedly aimed at high school teachers of physics and/or other sciences, preservice students of science, and accelerated high school students.

The program, comprising two semesters of eighty lessons each, was a very high level course in physics primarily for advanced undergraduates or graduate students in science teaching curricula. The course was organized and taught, principally by Dr. Harvey E. White, Associate Chairman of the Department and Professor of Physics at the University of California at Berkeley.

The first eighty lessons were organized around conventional topics in Classical physics, such as kinematics, dynamics, light, electricity and magnetism, but with deliberate emphasis on modern findings of physics and methods of approach.

The eighty lessons of the second semester were organized almost exclusively around topics in modern atomic and nuclear physics with a great deal of articulation between the latter topics and those presented in the first semester. An appreciable number of concepts not yet found in textbooks were presented.

Besides the principal teacher, a total of twenty-five guest lecturers appeared on the program during the first semester, and sixteen appeared during the second semester. Counted among the forty-one guest lecturers were eight Nobel Laureates.

The financial supporters of the program were The Bell Telephone System, The California Oil Company, E. I. duPont de Nemours and Company, The Ford Foundation, The Fund for the Advancement of Education, General Foods Fund, International Business Machines, Pittsburgh Plate Glass Foundation, and United States Steel.

The program was highly acclaimed by practically all leading science, science teaching, and educational association, and received no less than 10 awards for excellence in education and public service.

In addition to the physics course that was offered in 1958–59, "Continental Classroom" has scheduled a course in Modern Chemistry to be presented in 1959–60 The physics course will be presented on Video

tape from 6:00 to 6:30 A.M., and the new chemistry course will be presented from 6:30 to 7:00 A.M. The principal features and purposes of the chemistry course are essentially the same as those that were proposed for the physics course.

SOME OF THE PROBLEMS IN SMALL SCIENCE DEPARTMENTS

For at least ten years almost every major study concerning the problems of supply and demand of competent teachers of science, has revealed that the supply does not nearly approach the demand. The findings regarding the teachers of physics have been more appalling, particularly at a time when the findings and applications of physics are perhaps doing more to affect the lives of mankind than any other field of endeavor.

An ironic fact is that whereas about twenty years ago physics was almost a constant curricular offering, in high schools, a majority of the high schools were not offering physics as late as 1957. To be sure, there has been an increase in the number of high schools offering physics, but there is still great question as to whether physics is receiving anything near the attention it should in the American school (at the local level).

The foregoing statements are made with reference to physics in schools in general, but the situation in the small high school is much worse. Here, the science teacher often is not prepared to teach science at all. In many instances persons having preparation in English, social studies, physical education, and even music are assigned classes in science. Where there are "real" science teachers to be found, as often as not they have to teach "across the board" in science and mathematics, in addition to being assigned many other duties that impair their proficiency in teaching science and prohibit their chances of upgrading their instruction in their weaker areas, which more often than not include physics.

Many "prepared" science teachers who teach physics have studied but one year of the subject and could hardly be expected to do real justice to the subject today.

If the physics situation appears critical in the small high school, then it is quite as bad or worse in many small colleges which do not have physicists on their faculties. The writer reasons that it may be worse because the college represents the average prospective teacher's last chance to get a solid grounding in the principles of physics. Moreover, the smaller colleges, of whatever design, must train the majority of the teachers for the common schools. If colleges do not have individuals on their faculties who are competent to teach physics to the prospective teachers, how then can the chain of meager physics teaching be broken?

Competition with the larger universities, Government, and industry seem to make it virtually impossible for the physics situation in the small college to be remedied in the near future unless television or some other mass media are truly brought to bear on the problem.

THE APPARENT NEGATIVE REACTION TOWARD CONTINENTAL CLASSROOM

The Public relations staffs of The American Association of Colleges For Teacher Education and The National Broadcasting Company have consistently announced that "Physics For The Atomic Age" attracted an audience of approximately 270,000 daily. They reported that this number included 5,000 teachers, a number of engineers, dentists, physicians, high school students, and others.

The purpose here is not to question the authenticity of the public relations reports, but rather to raise the question as to whether as many science teachers and prospective science teachers were included as might have been.

A cursory glance at the list of institutions offering the course for credit reveals that the number was critically small in light of the existing problems, as alluded to above, and the total number of science teachers in America.

Authentic sources on higher education in the United States reveal that there were approximately 1,960 institutions of higher education in America in 1957. Of this total, there were approximately 1,400 institutions offering four or more years of training and more than 550 junior colleges offering at least two years of college training. A small number of the total purport to offer training exclusively for elementary school teachers. However, almost all of the listed institutions purport to offer at least one course in college physics.

In considering the substantial number of institutions that do not offer more than one year of college physics, it can be assumed that no more physics is offered because no more is required by their state certification laws. On the other hand, only one course is offered in a number of instances because often no physicists are available to teach and the available personned are not competent to offer more than the basic principles, and possibly not even those.

These facts would seem to dictate the necessity, or at least the desirability of more of the smaller institutions offering "Atomic Age Physics" than are listed among those colleges and universities that offered the course in 1958–59.

During the first semester of "Continental Classroom" which began October 6, 1958, there were roughly 250 colleges and universities offering "Atomic Age Physics" for credit. During the second semester which commenced on February 11, 1959, 275 colleges and universities stated their intention of offering the course for credit.

Interestingly and ironically enough, a substantial number, 146 of the institutions which offered the course the second semester were among the larger institutions which have relatively strong and large physics departments capable of offering bachelors or masters, and often doctors degrees in physics. In other words, many of the institutions needing help in upgrading instruction in physics were conspicuously absent, and many of those apparently not in such need were cooperating. Thus, the question as to whether "Continental Classroom" is reaching the audience that needs it most, naturally arises. This question is further accentuated when it is observed that an average of less than 20 students per institution were enrolled in the course. Considering the possibility that at least half of those 20 students enrolled were pre-service students of the various fields of science or science teaching, it becomes apparent that not many in-service science teachers profited from Continental Classroom, at least not officially.

Again, in light of the serious problems of instruction in physics in both small high schools and small colleges, the question as to whether "Continental Classroom" is truly "Continental" in its effect on science teaching is a serious one. The brief analysis presented above suggests that it probably is not, although it certainly should be. It is believed that more institutions should cooperate in this venture because practically every study that has been made to equate television teaching with conventional teaching has revealed the striking result that the former is at least as adequate as the latter.

MAKING CONTINENTAL CLASSROOM MORE CONTINENTAL

There may be many reasons why most of the institutions not listed as cooperating with "Continental Classroom" did not participate in this important venture in 1958–59. It was not a purpose of this paper to try to analyze such reasons, since to ascertain them would require a great deal of study, far beyond the present scope. However, a very obvious underlying cause of the apparent lack of interest by the colleges lies in the fact that the practicing teachers of science did not demand that the colleges offer the course for credit or non-credit. Moreover, some colleges give relatively wide publicity to the program, its objectives and possible accomplishments, but the response of the in-service teachers,

in their environs, was almost 100 per cent silent or negative. In other words, it could be said that there was no need for certain colleges to offer the course when there were no demands for it.

How can this situation be remedied? What can be done to increase the number of science teachers participating in this venture? There probably is no one set of answers but the following are some suggested approaches:

1. State school officers could use the prestige of their offices to encourage and persuade the colleges and other institutions under their jurisdiction to participate in the program. This could be done by offering special fellowships or scholarships from State Departments.
2. County and city school officials could encourage their teachers to take the course by offering special incentives such as upgrading in rank and pay, and possibly some time off from school duties in order that the teachers might have sufficient time and energy to adequately pursue the course.
3. Colleges with small science departments could upgrade their own programs by offering the course as an in-service seminar for their own science teachers who often teach in several fields. Also, where several small colleges are in close proximity, they could cooperate in such a venture for their science staffs and their better science students.
4. Colleges could allow more accelerated high school students to pursue the course for credit with the agreement that the credits could be transferred to other colleges of their choice.
5. State, county and city science teacher organizations could increase the number of their members pursuing the course by scheduling time for discussing the needs for more teachers to pursue the course, and the highlights of the program at their regular meetings during the year.

It would seem that these or some such suggestions will have to be followed if such ventures as "Continental Classroom" are going to truly serve the purposes which their founders and sponsors intend that they should serve.

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AN EXPERIMENTAL STUDY IN TEACHING HIGH SCHOOL BIOLOGY BY TELEVISION IN THE CINCINNATI PUBLIC SCHOOLS *

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With the widening horizons of educational television, the need for research in the use of the television medium in the instructional process is great. The purpose of this study is to determine the effectiveness of television in the realm of direct instruction in a public school setting. Specifically, the problem is to compare the relative effectiveness of television instruction with conventional classroom instruction on the basis of certain criteria.

High school biology was selected for several reasons as the subject to be taught experimentally by television in the Cincinnati public schools. In choosing a laboratory science such as biology for televising, each pupil thereby could see the details of experiments and specimens better, somewhat more elaborate demonstrations involving rather expensive materials were possible, charts and diagrams not available for every classroom could be constructed, and authorities from the community could appear as guest speakers. This experiment was conducted with a partial grant from the Fund for the Advancement of Education.

DESIGN OF THE EXPERIMENT

A full year course in high school biology was televised live from station WCET-TV, Cincinnati, Ohio. The telecasts were received by fourteen schools in the Cincinnati system, three of which were selected in advance to participate in the formal evaluation. One teacher and four biology classes in each of the three schools were involved in the experiment.

In each of the experimental schools, two control classes were taught biology in the conventional manner and two experimental classes alternated television and laboratory instruction during the same class period. While one experimental class with a proctor in charge viewed the telecast for the entire period, the other experimental class met with the regular classroom teacher for laboratory work, discussion, clarification, and elaboration of the previous day's lesson. The following day the telecast was repeated, making it possible for the two experimental classes to alternate. A regular classroom was set aside in each school and equipped with one television receiver.

The three schools selected for the experiment may be considered representative of schools in the Cincinnati system where biology is taught. Included in these schools is one school of well above average academic ability and one school of below average academic ability. The remaining school is considered average in academic ability.

Within each school, the four biology classes were taught by the same teacher. Pupils were randomly assigned to one of these four classes at the beginning of the school year. Two of the four classes in each school were randomly assigned to view television while the remaining two classes served as control groups and were taught biology using conventional classroom methods.

All four biology classes in each of the three schools followed the same course of study. The course outline was distributed to teachers and pupils before the experiment began. In this way, general course content and the amount of time devoted to the various units was approximately the same

* This study was conducted under the direction of Mr. Robert P. Curry, Assistant Superintendent of the Cincinnati Public Schools. The biology television teacher in this experiment was Mr. Stephen B. Smalley of the Cincinnati Public Schools.

for the television and non-television classes in each school.

COURSE CONTENT

The biology course was organized around eight major units as follows:

First Semester

I. The World of Living Things
II. Cell Life
III. Kinds of Living Things
IV. Green Plant and Food Supply

Second Semester

V. Human Biology
VI. Transmitting Life to New Generations
VII. Conserving Our Natural Resources
VIII. Man and Nature

The experimental (television) classes viewing television every other day, received 88 telecasts, each a full period (50 minutes) in length. The experimental classes viewed a total of 2,609 visuals via television. These visuals are categorized as follows:

Original drawings, charts, photos, etc.	422
Supers and name cards	685
Commercial charts, maps, slides, etc.	470
Experiments: special equipment and materials	300
Pocket charts, easel and blackboard	150
Plant and animal specimens	582
Total Visuals	2,609

Many unusual plant and animal specimens were shown, ranging from poisonous snakes and a baby gorilla to rare plants. In addition, thirteen guests who were authorities in their respective fields appeared on the telecasts. Among these were a museum director, a veterinarian, botanists, biologists, conservationists and physicians.

METHODOLOGY

Before valid comparisons between the television and non-television groups could be made, it was necessary to equalize, insofar as possible, each instructional "method" group with respect to pertinent factors. This was done in two ways: (1) statistically, and (2) by the method of organizing class units.

Experimental and control classes were rendered comparable statistically through the use of covariance techniques. Covariance analysis makes adjustments in final test scores to the extent that there are differences between the experimental and control groups initially. Thus, if one group is better initially than another, a constant "score" is added to the final scores of the other groups' scores. This in effect renders the two groups equal with respect to initial level of knowledge. The extent of this "correction" depends upon the correlation between the initial measure and the final measure.

In addition to statistical control over this pre-experimental condition, "control" was exercised also through the method of randomizing pupils with respect to classes, and classes with respect to the instructional method they were to receive. Randomization is the physical basis on which an attempt is made to prevent certain biases due to uncontrolled factors from influencing the results of the experiment.

Comparisons between television and non-television groups were made on the basis of three criteria; standardized achievement test results; a measure of knowledge about science and scientists; and the results of various ratings made by biology students in the television and non-television groups.

In analyzing the data obtained in this study, statistical tests were made in order to determine the significance of observed differences and also in terms of testing the validity of the assumptions necessary in the use of the various statistical techniques used.

ANALYSIS OF THE RESULTS OF THE THREE CRITERIA

Achievement. The Cooperative Biology Test, designed "to provide objective and reliable measures of achievement" in biology was used as the criterion of achievement. For purposes of covariance analyses, Form X of this test was administered as a pretest at the beginning of the school year. Form Y served as the post-test or final

criterion of achievement and was administered at the end of the school year.

The results of administering the pretest are shown in Table I.

groups, the difference between the two total methods averages will be reduced by a certain amount when appropriate adjustments have been made. This reduction, of

TABLE I

Average Scores on the Pretest, Form X, of the Cooperative Biology Test, for Television and Non-Television Groups within Each of the Three Experimental Schools in the Ninth Grade Biology Television Experiment, Cincinnati Public Schools, 1957–58

		Methods Averages				Total	
School	Ability Level	N	TV	N	Non-TV	N	Average
1	Below Average	54	43.44	54	43.09	108	43.27
2	Average	62	46.77	62	46.60	124	46.69
3	Above average	64	51.05	64	48.19	128	49.62
Total		180	47.29	180	46.11	360	46.70

Inspection of Table I shows that the total television methods average of 47.29 exceeds the total non-television methods average of 46.11. The television groups seem to be favored with higher initial levels of performance. It is the difference between the two total pretest methods averages that will be statistically reconciled in the comparison of the biology post-test averages.

The results of administering the post-test are shown in Table II. The averages shown in Table II are as yet unadjusted relative to initial levels of performance. Table II shows that the total methods

course, will result in a lowering of the total television methods average and a raising of the total non-television methods average.

After the post-test averages were adjusted statistically, a test was made to determine whether the differences between the television and non-television groups within each school were consistent in both magnitude and direction from one school to another. This test of interaction simply questions whether the effectiveness of one method over the other is uniform from one school or ability level to another. The results of this test indicated that the effectiveness of methods

TABLE II

Average Scores on the Post-Test, Form Y of the Cooperative Biology Test for the Television and Non-Television Groups within Each of Three Experimental Schools in the Ninth Grade Biology Television Experiment, Cincinnati Public Schools, 1957–58

		Methods Averages		Total	Difference
School	Ability Level	TV	Non-TV	Average	(TV-Non TV)
1	Below Average	51.06	51.43	51.24	— .37
2	Average	58.61	56.69	57.65	+1.92
3	Above Average	67.53	61.06	64.30	+6.47
Total		59.52	56.67	58.09	+2.85

average of 59.52 for the television groups exceeds the total methods average of 56.67 for the non-television groups. It is clear that since the initial levels of performance of the television groups on the pretest were higher than those of the non-television

was not consistent. Since the effectiveness of methods is seen to be dependent upon schools or ability levels, separate t-tests were computed for each of the three schools. The adjusted averages, differences between the averages, and t-tests indicating the

significance of difference between the television and non-television averages are shown in Table III.

TABLE III

POST-TEST AVERAGES ADJUSTED FOR PRETEST ACHIEVEMENT AND t-RATIOS INDICATING SIGNIFICANCE OF DIFFERENCE BETWEEN TELEVISION AND NON-TELEVISION AVERAGES WITHIN EACH SCHOOL, NINTH GRADE BIOLOGY TELEVISION EXPERIMENT, CINCINNATI PUBLIC SCHOOLS, 1957–58

School	Ability Level	Methods Averages TV	Methods Averages Non-TV	Difference (TV-Non-TV)	t-Ratio
1	Below Average	53.69	54.35	− .66	.52
2	Average	58.56	56.78	+1.78	1.51
3	Above Average	64.02	59.86	+4.16	3.72**
Total		59.04	57.15	+1.89	

** Significant below the 1 per cent level.

Table III shows clearly the source of the significant interaction. Inspection of the difference column in Table III shows that in School 1, the non-television groups did slightly although not significantly better than did the television groups. In School 2, the difference favored the television groups again but not significantly so. In School 3 the difference favored the television group and this difference is significant below the one per cent level.

Knowledge About Science and Scientists. One of the important objectives of instruction in biology, as well as other sciences, is to correct possible misconceptions about science as a discipline and about scientists as people. In addition, clearer concepts of the role of the various specialized disciplines of science and their relationship is an important objective of instruction.

In order to measure these objectives, the Test of Knowledge About Science and Scientists was constructed through the joint efforts of the Cincinnati Public Schools and the Educational Testing Service. This instrument is a seventy-item, multiple-choice type test and was administered to both experimental and control classes in each of the schools as a pretest at the beginning of the school year, and as a post-test at the end of the school year. Table IV presents the average pretest results of the Test of Knowledge About Science and Scientists for the television and non-television groups within each of the three experimental schools.

The total methods averages of 41.60 and 39.91 for the television and non-television groups, respectively, shows that on the pretest the television groups as a whole scored higher than the non-television groups as a whole. Inspection of the magnitude of the school averages shows the below average,

TABLE IV

AVERAGE PRETEST SCORES ON THE TEST OF KNOWLEDGE ABOUT SCIENCE AND SCIENTISTS FOR TELEVISION AND NON-TELEVISION GROUPS WITHIN EACH OF THREE EXPERIMENTAL SCHOOLS IN THE NINTH GRADE BIOLOGY TELEVISION EXPERIMENT, CINCINNATI PUBLIC SCHOOLS, 1957–58

School	Ability Level	N	Methods Averages TV	N	Methods Averages Non-TV	N	Total Average
1	Below Average	52	35.38	52	33.98	104	34.68
2	Average	60	41.52	60	41.13	120	41.33
3	Above Average	62	46.89	62	43.71	124	45.30
Total		174	41.60	174	39.91	348	40.76

average, and above average classification of the three schools to be consistent with the achievement test results.

The results of administering the same test at the end of the school year are shown in Table V. Inspection of the difference column in Table V shows that in Schools 1 and 2, the difference on the post-test favors the non-television groups while in School 3, the difference favors the television group. The total methods averages of 45.36 and 45.18 for the television and non-television groups, respectively, are seen to favor slightly the television group.

A test of interaction similar to the one mentioned in the analysis of achievement test results was made and found to be non-significant. Subsequent covariance adjustments in the averages of the six treatment groups are shown in Table VI.

TABLE V

AVERAGE POST-TEST SCORES ON THE TEST OF KNOWLEDGE ABOUT SCIENCE AND SCIENTISTS FOR TELEVISION AND NON-TELEVISION GROUPS IN EACH OF THREE EXPERIMENTAL SCHOOLS IN THE NINTH GRADE BIOLOGY TELEVISION EXPERIMENT, CINCINNATI PUBLIC SCHOOLS, 1957–58

		Methods Averages		Total	Difference
School	Ability Level	TV	Non-TV	Average	(TV-Non-TV)
1	Below Average	38.08	39.96	39.02	−1.88
2	Average	46.42	46.88	46.65	− .46
3	Above Average	50.45	47.92	49.19	+2.53
Total		45.36	45.18	45.27	+ .18

TABLE VI

POST-TEST AVERAGES OF THE TEST OF KNOWLEDGE ABOUT SCIENCE AND SCIENTISTS ADJUSTED RELATIVE TO PRETEST PERFORMANCE, NINTH GRADE BIOLOGY TELEVISION EXPERIMENT, CINCINNATI PUBLIC SCHOOLS, 1957–58

		Methods Averages		Total	Difference
School	Ability Level	TV	Non-TV	Average	(TV-Non-TV)
1	Below Average	41.82	44.68	43.25	−2.86
2	Average	45.89	46.62	46.25	− .73
3	Above Average	46.19	45.86	46.02	+ .33
Total		44.78	45.77		−1.01

The difference of −1.01 between the total methods television average of 44.78 and the total non-television methods average of 45.77 was found to lack statistical significance. It may be stated, therefore, that the television method of instruction and the regular classroom method of instruction are about equally effective as measured by performance on the Test of Knowledge about Science and Scientists. It is interesting to note the trend in the difference column. The effectiveness of the television method seems to be directly related with the ability level of the school. This trend was noted also in analyzing the achievement test results.

Student Rating of Biology. In order to evaluate adequately televised instruction in biology, an attempt was made to measure certain attitudes toward biology by comparing responses made by pupils viewing televised biology with those taking biology in regular classroom situations.

The instrument used for measuring these attitudes is called *Sizing Up Your School Subjects* and was constructed by the Educational Testing Service. This instrument consisted of ten items, each intended to measure certain dimensions of attitude toward school subjects.

It was administered to the total ninth grade population in each of the three experimental schools used in this study. From this total group, the classes from each school

designated as experimental and control were singled out for analyses. During the administration of this attitude survey, pupils were not informed that its basic purpose was to measure attitude toward biology. Pupils were told further that their responses would have no influence upon school marks and would be kept anonymous. In this way, it was felt that honest and straightforward responses would be given by the pupils responding to the questionnaire.

The methods of analysis of variance were applied to the data to determine the significance of observed differences in averages between methods, schools and the interaction between methods and schools.

Rather than present detailed tables of the results of the analysis for each item, the following summarization may be made:

1. Pupils taught conventionally tended to "like biology more" than did pupils taught by television.
2. Pupils taught conventionally had a "greater opportunity to ask questions" than did those taught by television.
3. Pupils taught conventionally felt that biology was less a "waste of time" than did pupils who were taught by television.
4. Pupils taught conventionally felt that teaching in biology "got across" better than did pupils taught by television.
5. Pupils taught conventionally felt that "more serious discussion took place" than did pupils who viewed television.
6. Pupils taught conventionally felt that their "mind wanders" less than did pupils taught by television.
7. Pupils taught conventionally felt that they "learned more" of biology as compared to pupils who were taught by television.

The generalizations listed above apply to all schools included in this experiment. In three of the ten items, a significant interaction between methods and schools was present. In each of these three items, School 3 was apparently the source of the significant interaction. It is interesting to note that School 3 is the above average ability school.

For the item, "How much time do you actually spend on the subjects you are studying," differences between methods within two schools were found to be significantly different. In the below average ability school, the non-television group tended to spend more time studying biology than did the television group. In the above average ability school, pupils in the television group tended to spend more time studying biology.

For the item, "How much do your subjects conflict with your outside activities," the only significant difference between methods occurred in the above average ability school. The television group felt that biology conflicted more with outside activities than did the non-television group. This response is probably a reflection of the greater amount of time the television group spent studying biology as shown in the preceding item.

For the item, "How easy to learn are the subjects you are studying," only the above average ability school showed a significant difference between methods. The non-television group felt that biology was "easier to learn" than did the television group. Perhaps the greater difficulty in learning biology by television in this school is the cause of the greater amount of time the television group spent in studying biology.

On the whole, the results of this questionnaire tend to indicate that as measured by this instrument, pupil attitudes favor conventional classroom methods of instruction.

DISCUSSION OF RESULTS

It was noted in the results of the achievement test that the television method of instruction was significantly more effective than the non-television method in the above average ability school. Although the differences in the average and below average ability schools were not significant, there was a trend for the effectiveness of television to be related directly to the ability level of the school. This trend may, in reality, be a reflection of chance variation. The same trend, however, was present in the results of the Knowledge About Science and Scientists Test. Although the results of the

latter instrument showed no significant differences, nevertheless, the trend toward greater effectiveness of television with higher ability pupils was present.

Assuming a significance of this trend, one of the most pressing questions arising from this investigation is whether there is an intrinsic association between the effectiveness of television instruction and the ability of the pupil.

It is difficult to rationalize on logical grounds why the television medium should be of more benefit to the more able pupil. One may hypothesize that the increased effectiveness of television instruction is a function of the ability level at which the instruction is geared, the pace at which it is presented, and the amount of instruction attempted. It is apparent that if television instruction is geared to the above average ability pupil, at a faster than average pace, and with a greater quantity of material covered, it is the above average pupil who will benefit the most. If, on the other hand, television instruction is geared to the below average ability pupil, then it is likely that the below average ability pupil will benefit proportionately more than the above average pupil.

It is probable that the explanation, in part at least, is due to the fact that teaching by television results in a richer and broader curriculum. The teacher, because of the nature of television and because of the absence of normal teacher-pupil interaction found in the classroom, provides a broader instructional program, although obviously not without sacrifice. This tendency has been noted by both classroom and television biology teachers. It is probable that the more able pupils profit more from this type of instruction.

The lack of significant differences at the average and below average levels of pupil ability is possibly a reflection of the homogeneity of the groups involved within this experiment. In the below average school, for example, the pupils who elect biology tend to represent a brighter segment of that school population. Thus, with relatively small differences between biology groups, it is obviously more difficult to discern, through the use of objective tests, a consistently significant trend.

If the foregoing points of view are correct, it is clear that the principles of instructional methodology are not uniquely different because of the television medium. Rather, the same principles which bear on regular classroom methodology should be used in guiding the effective use of instructional television.

The less favorable attitude toward biology by those pupils in the television classes may be due to many factors. It is believed, however, on the basis of observation throughout the year, that one important factor was the length of the telecast. In all probability, fifty minutes of instruction by television is too long a period.

EXPERIMENTING WITH AN ACID CHAMBER

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RARELY does the high school student, the beginner or the enthusiast have the opportunity to naively experiment and the luck to succeed. Although I had four years of mathematics plus one year each of chemistry and physics, I was ignorant—but hopeful.*

I wanted to build a new type of cloud chamber that would be amazingly simple and dependable. I did not realize then that my physics project would lead me into chemistry, photography, and other fields.

* Editor's Note: Mr. Hudson is a high school student who completed this experiment under the supervision of his physics teacher, Mr. Carl H. Zwinck.

Although the work itself was simple, the thinking it stimulated was complex. My work could be duplicated and continued by other science students. This article has been written to encourage this, and because original creative research can be done with this approach.

Actually any chamber performs a simple operation depending on such basic concepts as boiling point and condensation conditions. Yet, beginning with temperature control, cloud chambers have become notoriously unreliable and as unpredictable as the "space rays" they picture. Accordingly the experiment centered about the simple essentials of chamber operation.

The first essential was a ready-made chamber, a mason jar, which I decided to use to hold a dense atmosphere. When just above the dew point, a saturated atmosphere will condense about any particles present, including dust or moving cosmic particles. These space trails gradually subside, and permanent records are necessary for scientific investigations, so I next considered the possibility of using corrosive droplets settling upon a corrodable platform.

I mounted a strip of aluminum above a board and fastened a mason jar top bottom-side up on the aluminum strip. Through a hole in the mason jar top a rubber tubing was connected to a squeeze bulb. I planned to introduce some kind of acid, probably a gaseous anhydride, into the chamber. Later I would add water in solution with methyl alcohol.

I prepared hydrogen chloride gas by the usual $NaCl$–H_2SO_4 reaction and collected it in a mason jar by displacement of methyl alcohol. Using the rubber squeeze bulb, I added a mixture of four parts of alcohol and one part of water through the rubber tubing. With the mixture in the mason jar and the apparatus intact, I used a sun-lamp or heating pad to heat the mixture to an arbitrary 100° F. I recooled to 80° F. and moved the apparatus to the basement. There the temperature became 50° F.

The results were repeatable. A white powder formed on the neck of the chamber. After cooling, definite lines formed in the powder. Had alcohol actually condensed from vapor trails and washed away trails of powder or were they cracks in the coating?

I began a study of the coating itself which led me to the experimental deformation of plastic sheets and other experimental work dealing with reactions of acids upon various materials. I later found that such studies are used in the research and development work related to some materials used in industry, where similar quality control techniques are used.

I also studied the action in my chamber by varying concentrations and temperatures. I determined pH with suitable indicator papers. I am continuing experimental work using various experimental variables in controlled experiments. Many questions remain to be answered.

I collected data which I recorded in tables and in photographs. Objectives were selected in the beginning. They were design of a dependable chamber, easy recording techniques, and elimination of complex controls. Design, invention, and elimination were three of my areas of investigation. Others of a creative nature presented themselves to me later. Although following directions in a laboratory manual is not very stimulating, the challenges provided by original research which science students can do in the classroom or at home are very motivating.

A COURSE IN CONTEMPORARY DEVELOPMENTS IN THE SCIENCES AND MATHEMATICS

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BACKGROUND

WHEN in 1951 a new program for the Master's Degree in Elementary Education was in the planning stage at our college, our administrative officers concurred that it should include a year-sequence in General Education instead of being solely devoted to professional education. This sequence was to acquaint the graduate student with contemporary developments in the Humanities, the Natural, and the Social Sciences.*

A perusal of the literature quickly revealed that this undertaking was somewhat unorthodox in that only one or two references were found about courses of a similar nature at other institutions.

The actual planning of this course thus became a venture into new territory instead of the more usual implementation of an already well-established course, and for those who looked for a text as a hitching post for this new course the dilemma was soon apparent. The usual student background of only one year of biological science and one year of physical science presented another obstacle to any interpretations of contemporary work in science at least as far as depth of understanding is concerned. Finally, not the least of the problems was to find instructors having both sufficient interest and sufficient breadth.

With the original objective and all of these limitations in mind, a rough preliminary course outline was drafted and the following course description written:

Sc 511 Contemporary Developments in the Sciences and Mathematics. 3 hours.
Emphasis upon the more important phases of contemporary developments in the natural sciences and mathematics. Evaluation in terms of historical background, the true aims of science, and the effect upon society. Review of related regional problems and resources. Selected readings.

One of the first hesitations the initiate faces is the concern for the "Mathematics" part in the course title. The background of the students in mathematics is unfortunately even more limited than their backgrounds in the sciences. At the same time, most of the contemporary developments in mathematics require considerable depth. Inasmuch as mathematics is sometimes considered to be an integral part of the natural sciences and with all the afore-mentioned limitations, plus that of time, separate emphasis in the title upon mathematics is questionable.

COURSE ORGANIZATION

I. Introduction

Any course should include a proper introduction before venturing into the main body of the subject matter, but it appears especially important that this course be placed in its proper perspective. It is for this reason an extra, i.e. more lengthy, effort is made to acquaint the student with the whole scientific enterprise. Actually, this course by its very nature does not have a body of well-defined course content considered requisite to any other subject area, but is almost the scientist's last opportunity not only to acquaint the students with contemporary developments in the natural sciences but also to interpret science itself to prospective laymen, laymen whose functions and views as workers with students and teachers can be of considerable importance to the future of science itself.

* Students at the Oregon College of Education are now required to take two one-term sequences in the General Education program and in addition a whole year in one of the three areas listed.

The topics discussed in the introductory portion follow in outline:

A. Aims and Purposes of Science
  1. Basic definitions
  2. Brief historical setting
  3. Philosophy and methods
  4. Science and technology
B. Organization of the Natural Sciences
  1. Pure sciences, their subdivisions and particular objectives
  2. Applied branches and their interrelations
  3. Interdisciplinary approach
C. Scientific Research
  1. Pure vs. Applied
  2. Status of research in U.S.A. and Abroad
  3. Research functions of
    Universities
    State Colleges
    Liberal Arts Colleges
    Technical Institutes
    Industry
  4. Sponsors of research and extent of their participation
    Government at various levels
    Educational institutions of various types
    Industry and other private organizations
D. Scientific Manpower (Science and Scientists)
  1. Personality and Education
  2. Supply at home and abroad—fellowship programs
  3. Scientific organizations
  4. Scientific distinctions—Nobel Prizes
  5. Secrecy and security

II. Main Part of the Course

A. *Outline.* Without proceeding any further, it is evident that any attempt at coverage of the field would not only be impossible but would also lead to superficiality. An organization along well-defined disciplinary lines was also abandoned in favor of an organization around a few central topics. In the following outline of major topics a few suggested subtopics have been included.

1. Earth
  Dating and age
  Geophysics
  Meteorology and climatology
  International Geophysical Year
2. Life
  Origin
  Photosynthesis
  Food and health
3. Raw materials
  Metals and corrosion
  Rare earths and artificially prepared elements
  Polymers
4. Energy resources—current and future
  Fossil fuels
  Nuclear
  Solar
5. Universe
  Cosmology
  Radio astronomy
6. Electronics and automation
7. Mathematics
  Binary number system and its use
  Use of statistics
  Topology

The choice of major topics should not be looked upon as fixed but subject to change and certainly in emphasis according to an instructor's background and interests. As has already been mentioned the subtopics are only suggestions which may vary from time to time. The emphasis throughout the course, however, should be on understanding of current developments on the basis of fundamental principles which must constantly be briefly reviewed. This means, of course, that the actual number and choice of topics has to be made rather carefully.

B. Implementation. The course is now largely organized on a lecture basis. With the limited amount of time available both students and instructor have felt that the instructor could likely make the best use of the time, and student reports have been rather unsuccessful though frequent discussions ensue from student questions.

Each student selects a topic for a term paper which is largely based on a brief review of the literature at his level of competency. This paper may be from the areas of pure or applied research, or it may be on one of the contemporary issues confronting society which have distinct scientific implications such as smog, fallout, weather, etc. In addition to the term paper, a regular written final examination is given which samples the student's reading as well as his comprehension of lecture materials. A few well selected films and a field trip have been successfully used on occasion.

The main source of reading material has been from the *Scientific American* including the *Reader,* more recently the *Books,* and the magazine itself. This magazine is an

excellent source for people interested in breadth, and it is also of sufficient depth for this group as its successful use in the course has certainly demonstrated. However, many other sources, such as books, periodicals, governmental and industrial publications, have also been extensively used, and the students are furnished with a mimeographed bibliography.

CONCLUSIONS

This course has now been offered at our college a number of times and by different staff members both resident and visiting. We are currently experimenting with the participation of cooperating instructor(s) from special subject areas. We are also, on the basis of our present experience, contemplating similar work for prospective secondary teachers. Because of the greater subject matter preparation of these students the courses would be more restricted in scope by devoting a whole term to either the biological or physical sciences.

The experience of this writer as one of the instructors has been most challenging and at the same time rewarding and interesting. In spite of the many reservations expressed at the outset, this course represents a unique opportunity of informing laymen about the true aims and purposes of science and many of the exciting developments of our time. The only alternative is to say that these people do not have the background for graduate work in science and therefore offer them none. I, for one, as a worker in science, would rather have the present opportunities to help people understand science and possibly win them for science than not to have it.

A DEVELOPMENT IN PROCESS: THE SCIENCE CURRICULUM IN THE WHITTIER UNION HIGH SCHOOL DISTRICT

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DURING the school years 1953–54 through 1956–57, a Science Curriculum Study Committee including the science teachers and department heads of the Whittier Union High School District has worked on the re-evaluation of the science curriculum under the chairmanship of Mr. James T. Robinson. Without the splendid leadership provided by these teachers and department heads, the developments described in this article would have been impossible. During this period of time, the department heads were: Mr. Myron D. Claxton, Whittier High School; Mr. Peter DeVries, El Rancho High School; Mr. Jack E. Jines, Santa Fe High School; Mr. James T. Robinson, California High School.

During the period beginning with the school year 1953–54 and continuing to the present time, a ferment of exploration and experimentation has characterized the evolving pattern of science instruction in the Whittier Union High School District. The concern with the effectiveness of instruction in the science program, born of the dissatisfaction of many science teachers with what seemed to them to be a less than adequate program of science instruction for terminal students in Applied Science, has spread to encompass a searching re-evaluation of the entire scope and sequence of instruction in science. Beginning with the desire to improve instruction for one group of students, all students are now the concern of the Science Curriculum Study Group. Feeling an equal responsibility for the education of terminal, general college preparatory, and science career students, the curriculum group is currently working on the development of a "track" sequence for

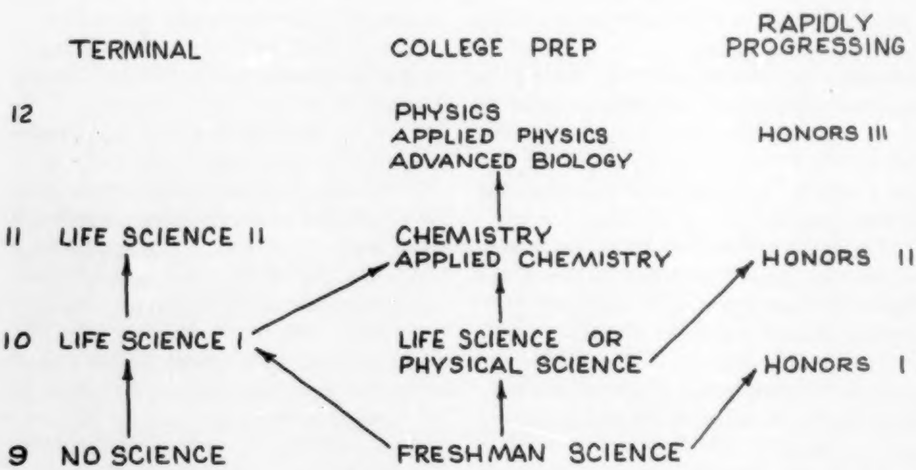
each of these special groups of young people. Development in thinking about the role of science in modern life has led the curriculum group to the general acceptance of the idea that a science curriculum in the secondary school should provide an equally vital learning experience for each of these groups of young people over a possible four year sequence of courses. It is a general agreement within the curriculum group at the present time that all functioning members of our society need to be aware of the basic understandings which evolve from a study of both the biological and physical sciences. There is a rather firm commitment among these science teachers that factual accumulation of data is not sufficient alone to develop the kind of reasoned awareness that living in a scientific society demands. Thus, there has been a continuing effort to improve the instructional vitality of work in science at all grade levels. There has been a consistent attempt to involve students more directly in project or experimental work which would allow them to utilize the knowledges which they already possess, to ask questions which point the way to new knowledge to be gained, to implement the process of scientific inquiry through direct application, and to find through such inquiry some of the limitations of science.

One of the first tasks which the curriculum committee set for itself, when it began its work, was the definition of the goals of science instruction. When the goals were first developed they were applied exclusively to instruction in the tenth year course in Applied Science. As further discussion has taken place, re-evaluation of this goal statement has led the group to feel that it is a rather general statement which is fairly applicable to instruction in the total high school science program. These goals then stand as the purposes which should be fulfilled for each student in high school in the area of science instruction:

Science instruction should:

1. Give the student the experience of making actual scientific investigations in the area of science and of developing an understanding of the nature of scientific inquiry and of understanding the limitations of science when applied to human affairs. That within this general goal science should:
   a. Help the student recognize problems real to him and help him set them up so that sound solutions are possible.
   b. Help the student learn how to gather and use data in working on problems.
2. Help the student to dispel superstitions and erroneous beliefs about common happenings.
3. Contribute to the development of the student's esthetic appreciations of the orderliness of nature and the beauty of natural things.
4. Contribute to the development of the student's satisfactions regarding good workmanship, originality, creativeness, and efficiency.
5. Enable the student to better understand these scientific principles which are at work in his environment:
   a. Law of the conservation of matter and energy.
   b. Germ theory of disease.
   c. Atomic nature of matter.
   d. Cell structure of living organisms.
   e. Differentiation and specialization of bodily functions.
   f. Balance of Nature.
      (1) Food chains
      (2) Cycles
   g. Fundamental law of input and output.
   h. The dependence and interdependence of living and non-living things.
   i. Evolution.
   j. The nature of inheritance.
   k. Nature and organization of universe.
6. Help the student to develop wholesome attitudes and scientific understandings regarding the development of the human body.
7. Help the student develop sound health attitudes, understandings, and habits.
8. Help the student develop a scientific interest and acquire scientific knowledges which will contribute to worthwhile recreational and leisure-time activities.
9. Help the student to understand the nature of matter, the significance and potentialities of atomic energy, and the effect of these on his life.
10. Help the student develop discrimination in the selection and evaluation of scientific information intended for the layman.
11. Help the student to understand the necessity of conservation and to become conservation-minded, thus, developing good conservation habits, attitudes, and practices.
12. Help the student understand the physiological effects of narcotics, alcohol, and tobacco.
13. Help the student be aware of the hazards of combustible materials.
14. Help the student to become aware of the importance of sound safety practices.

As consideration turned from concern with only one group of high school students to the development of an effective program for all students, one problem was to investigate ways of organizing the scope and sequence of science experiences in such a way as to provide an equally challenging and vital experience for each group of students which had been identified as needing special curricular adaptation—terminal, general college preparatory, science career or "honors" students. Discussions on tracking have developed to the point where the following schematic outline is illustrative of current thinking:



units of instruction was the constant focus in these meetings upon the growth and development characteristics of adolescents, the developmental tasks which they were facing and would face in the future, and the knowledges, attitudes, and practices which science instruction would need to implement if the next stages of growth were to be achieved by these young people. There was a constant attempt throughout these meetings to test instructional experience against this criterion of facilitating maximal individual and group growth toward maturity. As this testing procedure progressed, the teachers sought in their discussions and study for a type of instruction which would more nearly facilitate growth in understanding and skill in the use of the methods of science than had the more traditional approach of teaching the history of science. Much that is now seen throughout the District as the experimental approach or project method of instruction was discussed in the idea exchange of these meetings. Some teachers today see the project or experimental approach as a method of teaching; others see this approach as an activity which may be utilized from time to time within a more formal structure of experience. But regardless of how pervasive or incidental the project approach is in the

Possibly the most significant development to date, growing out of this period of rethinking of the District's science program, has been the vitalization of science instruction. During the school years 1953–54, 1954–55, and 1955–56 the Science Curriculum Study Group developed a weekly or bi-weekly pattern of meetings. First concern in these meetings was directed toward Applied Science—the development of goals and units of instruction. During the meetings where intensive concern was given to the development of units of instruction, there was a rich exchange of methods, procedures, skills (descriptive), and materials. Integral to the development of these

teaching pattern of any one teacher, as a District pattern, more students are more frequently being involved in active creative research in science than was true in the past. More frequently today we find that students are searching for problems which are real to them and following through the experimental process to solutions of such problems. Fewer students today are working on problems which the teacher considers significant and worthy but which may not have such significance or worthiness to the student. During 1954–55 a brief summary of some of the types of projects which students had developed was summarized. These examples illustrate the type of activity which we find more frequently occurring as teachers stimulate student interest in pursuing inquiries which enable students to actively utilize the methods of science in arriving at solutions to problems. Needless to say, the following examples are some of those which represent rather outstanding student effort:

Jim placed radioisotopes of phosphorus in water and allowed gold fish to live in the water for four days. The fish were then dissected and radioautographs made of the skeleton. His findings indicate that the most extensive deposits of phosphorus have localized in the bones of the abdominal and cranial areas.

Frank, Bill, and Tom have brought 50 gallons of ocean water for the built-in aquarium on their own time. They stocked the aquarium with marine animals and kept it functioning for about one month. Now they are busy setting up a fresh water aquarium and are bringing in fresh water animals for study.

Kenny is building a galvanometer. This will be a multi-purpose instrument with variable resistances.

Dick has synthetically developed smog from the reaction of hydrocarbons and ozone. He has built his own ozone generator and has tried to complete the ozone, hydro-carbon, nitrogen dioxide cycle. He doesn't yet feel that his test is reliable.

Janice, Donna, and Sally have been working on a comparative study of the development of the chick embryo as contrasted with the development of the human embryo. They secure fertilized eggs and through an incubation process secure the chick embryos. They are trying to secure embryos which will depict each day's growth in the anatomical development of the chick.

Ronnie is making sulphuric acid by the contact process. He makes his own oxygen which he combines with sulphuric oxide. He passes this mixture over a platinum asbestos catalyst. He must control the temperature carefully and is, thus, trying to develop a thermo-electric thermometer.

Nancy and Barbara are producing a serum, inoculating healthy rats, and testing the effects.

Charles and Dennis are making radioautographs of gold fish.

There are a number of students studying the inheritance of physical characteristics in white rats.

Allan, a junior boy, has been carrying out a study of transistors. He has entered the Science Fair for four years in his 8th, 9th, 10th, and 11th grades. This boy is constantly at work on independent study in the physical sciences.

Paul and Tom are doing outstanding work in growing crystals.

Carl, working in Botany, is trying to germinate dissected seed embryos in nutrient solutions. He is setting up a bog terrarium and is going to germinate spores of ferns and bryophytes.

Jim, also a Botany student, is testing the effects of different soil types on house plants.

Lee, working in Botany, is experimenting in hydrophonics. He is trying to grow seeds in nutrient solutions. He has had to make much of his equipment to operate his experiments.

Barbara, working in Advanced Biology, was culturing flat worms and while doing this noticed some changed in color to red.

She is now trying to determine why the color changed.

Tom is working on a continuous cloud chamber to be used in the study of radioactivity. He has been working over a year now on this project and is becoming quite an authority on the subject. He is trying to work on his cloud chamber by using regular rather than dry ice.

Although these projects represent outstanding work, they are indicative of the kinds of science projects which teachers have been encouraging students to undertake. Encouragement of this freedom of inquiry culminated in 1956–57 in students from the Whittier Union High School District being awarded nine of the twenty-seven top awards at the Southern California Science Fair. Additional impetus was given to the stimulation of interest in scientific inquiry by the development of the first Whittier Union High School District Science Fair which was held prior to the Southern California fair and in which approximately 30 elementary and junior high school students and 100 high school students entered exhibits. Again, utilizing the principle that cooperative efforts produce a higher quality product, this District fair was an outgrowth of a year-long cooperative planning effort in which students, teachers, and industrial and business leaders participated. Each subcommittee of the Science Fair Planning Committee was under the joint chairmanship of a faculty member and a student. Industrial and business leaders participated in one general planning meeting and in numerous meetings of the steering committee. This steering committee of teachers, students, and industrial and business leaders coordinated planning for both the Science Fair and Mathematics Contest.

Throughout the development of the science curriculum study, the mathematics departments of the District have been equally concerned with a reappraisal of the District's mathematics program. As each committee's work has progressed, the two inquiries have tended to move toward a closely articulated development. Recently, when the developments in the science study were reported, it was only natural that developments in the mathematics curriculum group would also be reported. The close relationship between these two fields of work are being constantly explored and present experimental work is examining the possibility of a mathematics curriculum pattern that parallels the tracking proposals for science.

Just as students have been stimulated to do experimental work, so have teachers. Currently there are long-term evaluative projects being developed in an accelerated science program (10th grade—Chemistry, 11th grade—Advanced Biology, 12th grade —Physics. For the future it is hoped also to try reversing the grade placements of Physics and Advanced Biology.), a study of "gifted" pre-science career students, and evaluation of the outgrowths of Freshman Science taught as a general introductory science as contrasted with it taught as an exploratory science.

Stimulation of the re-thinking of the science curriculum which has been in process in the Whittier Union High School District finds its source in a number of circumstances. Among these, the following seem to be of particular significance:

1. Dissatisfaction with the course of instruction in Applied Science.
2. The creative imagination and enthusiasm of the teachers in working with this concern.
3. An administrative orientation which seeks to stimulate constructive change rather than to deter such change.
4. Provision of time for department head supervision and coordination services by District personnel.
5. Availability of the resources for intensive study of problems posed by the curriculum study: research studies, curriculum materials, consultant help, etc.
6. The current nation-wide concern with the future possible shortage of trained scientific talent.
7. The current, less pervasive, nation-wide concern of many thoughtful people with the knowledges and understandings which are necessary for societal survival in an increasingly scientific age.

Possibly points three and four should be discussed since it is in these areas of facilitation that many good ideas fail of generation. The administrative environment within which teachers work is possibly the most crucial single aspect which either deters or encourages creative educational improvement. The definition of such an environment is difficult to arrive at because in its essence it deals with certain attitudes relating to how professional adults work with one another. When concepts of line and staff define who can offer valid ideas, then the tendency is to stifle the development of original ideas within the teacher group—or, if the ideas are not stifled, the constructive behaviors associated with them are not allowed to become active elements in a process of change. But, if we grant that administration is willing for problem areas to be defined, what then should be some of the qualities of the problem solving situation? Some of the attitudinal and operational aspects of such a relationship, as we have found it to be, are as follows:

1. The willingness to come to the curriculum building, or problem solving situation, "as you are" without pretense to skills and knowledges not possessed.
2. The willingness to participate in problem solving, to test one's ideas on the anvil of the minds of others, and to abide by the solutions developed.
3. The willingness to discover personal or group inadequacies and to seek the resources for building knowledge, understandings, or skills where any of these are lacking.
4. The willingness to project experimentation upon the best of available knowledge rather than upon personal opinion or prejudgment.
5. The fundamental belief that all participants are learners and that each because of his unique qualities or function can best serve in certain roles.
6. The fundamental belief in the individual worth of each participant and a faith that each can continue to grow if given the opportunity.
7. The recognition that each participant, in regard to any one human characteristic, is probably somewhere in the continuum of development as to make him somewhat unique from any other participant.
8. The realization that evaluation is made in terms of certain specified or developed goals, that it is always insufficient to the assessment of full growth, that it is a composite of the perceptions used in assessment, and that it is always relative to the opportunities for and qualitative validity of such assessments.
9. The understanding that evaluation is an integral and essential aspect of any learning experience and of the process of curriculum improvement.
10. The opportunity to "chew and spit" ideas and to reconstruct previous learnings in an atmosphere which continues to accept the individual even when the ideas he expresses may be challenged.
11. The opportunity to call upon resources outside the district—human and physical—when there is readiness and need.
12. An understanding that the use of resources outside of a particular school or district is an acknowledgement of strength rather than weakness and an indication of maturity in staff relationships.

Certainly these few statements of the characteristics of an administrative atmosphere, or way of working, which is conducive to continuing growth in professional personnel form only a partial statement of the necessary conditions for such growth. However, as fairly pervasive aspects of the curriculum development process as it has been developed in the Whittier Union High School District, they represent in part the reason why science curriculum revision has developed to the point at which it has been described in this brief recounting of a four year period of development.

GENERAL SCIENCE IN THE SECONDARY SCHOOLS

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The problem of the nature of ninth grade science is becoming increasingly difficult. Many students of science education have presented their ideas on the present dilemma. The purpose of this paper is to give some background as to the nature of the problem facing teachers of general science courses, to summarize present thinking about general science, to build a description of what seems to be suggested as a more "ideal" general science course from the standpoint of students of the subject, to then examine from personal experience and that of other general science teachers, the major obstacles which prevent teachers from providing this type of program in their own schools. In this manner, perhaps a direct attack on overcoming some of the major blocks may be made.

Richardson [6] has summarized the present offering by two rather key statements, (a) general science at present is largely descriptive in nature, (b) it seldom provides for individual laboratory work. Furthermore, general science, if one can use the current textbooks as a clue to the nature of the course as generally taught, is a survey of many subjects of both physical and life science.

Smith [14] has shown that the number of schools offering ninth grade general science has increased by 10 per cent in the period, 1945–1955. Johnson [4] states that the enrollment in ninth grade science in the United States for the year 1948–1949 was 21 per cent of the pupils in the last four years of public school.

Harlow [7] has done a thorough job of discounting the common hypotheses which have been proposed to explain why present day science instruction is failing to meet the needs of society in providing both the needed scientific manpower and a science literate population. The need for the erection of a new educational policy is widely agreed upon by examining the current discussions by manpower students and leaders in government and industry. At present, however, there does not seem to be any agreement as to the details of this new policy. Harlow states that "science and mathematics in the schools can in no way be said to represent the enormous place of science and mathematics outside the schools."

In a search for guide lines to planning for this new educational policy one finds a divergency of opinion, especially if he consults those whose knowledge of secondary science teaching is at best indirect. Brandwein, who has been successful in developing curricula which have been productive in the numbers of students placing in the Westinghouse Science Talent Search states [2] "The purpose of general science is to teach so well and so leisurely that students will want to take more science. In order to do this you must deal with material that is so interesting that they want to study more. Out of this experience in the general science exploratory course at the ninth grade level students discover their own particular abilities and limitations in science study and thus are able to choose the appropriate (science) track for themselves in the tenth year."

Bronowski [3] states ". . . we need to teach science, even at school, not as a collection but as an evolution of knowledge. I think this is important for three reasons. Because it sees science as a development, it offers links with history and literature and geography that can give help and a vivid perspective to the nonscientist. Because it presents science as changing, questioning, and argumentive, it can teach the methods of rational debate to everyone in the classroom, and this can be a lifelong

lesson. But more important, the evolution of science goes to the heart of the scientific method: for it shows at each step how the logical deduction from what seems to lie behind the known facts must be confronted with experience. We make an induction, we put the deductions from it to test, and on the results of the test we base new induction. This to and fro between the logical and the empirical is the core of the scientific method, which nonscientists never seize because they do not see science as a progress. To these general points I will add a fourth. It is that every boy and girl, every undergraduate, should do one small piece of personal scientific research."

Brandwein [2] adds further that the science curriculum must be built around the "developmental tasks of youth" as developed by Havighurst [8].

Dr. Hurd, in a course in science education at Stanford University, 1957, has stated that a general trend in science curriculum is toward greater selection of subject areas within a given course, with less "coverage" of a field, and a consequent greater depth of study in a few areas.

In the Whittier Union High School District, a group of interested science teachers studied the problems of scope and sequence in science, grades 9–12 during the school years 1953–54 to 1956–1957. As a result of their studies, they recommended that the survey type general science course be replaced by a more exploratory course which would allow for greater individual laboratory work on the part of the student in the solution of problems having meaning for him. A committee is at present working on the actual development of such a curriculum.

From these data, and from general reading in the area, the writer is developing the remainder of this paper on the following assumptions:

1. In the future more schools will require science each year, at least through the 10th grade of all students.
2. Increased experience with science on the part of 9th grade students will demand a continuous reevaluation and reorganization of the 9th grade science program.
3. Students will enter the 9th grade with greater and greater differences in their experiences and understandings in the field of science.

These assumptions will make it increasingly necessary for ninth grade science teachers to know the kind of experiences students have had in previous grades. In addition to this, because of the number of out of school experiences which students are meeting with science, some type of instrument will need to be developed in order for the teacher to assess the scope and depth of understandings which students have. This in turn will make it necessary for a school district to make a basic policy decision as to the advisability of grouping pupils in general science. Although class sizes, at least in California, seem to be increasing in size, much of the literature emphasizes the need of direct experience for students in using the laboratory for problem solving. This trend in class size will need to be reconciled with this problems-approach to classroom procedures. Whether the school district decides to group or not, the teacher will be confronted with the need to provide a wide range of experiences in each area of study if we are to achieve maximum development for each student.

From the literature cited and from many other sources pertaining to the nature of adolescent youth, the developmental tasks, and the nature of the learning process, it might be well to attempt to describe the nature of a "new" educational policy, specifically, a description of a more ideal course, designed to conform with the findings and recommendations cited. This description will of necessity be brief, and may leave out some aspect of such a program. After examing this theoretical program, we can analyze some of the blocks which prevent some classroom teachers from implementing such a program.

The first thing we would notice about such a program is that it captures the interest of 9th grade students. It generates, or sustains interest in science which carries

over to leisure time activities and to selection of further study of science in the secondary school. It also enables the student to use his mathematical skills and have more experience in utilizing mathematics to describe as many of his findings as is practicable, and enables him to understand mathematics as applied to real problem solving.

In this class we would see students discussing problems real to themselves. In attacking such problems, many kinds of activities would be employed. Students with different abilities and interests would be doing different kinds of things in order to develop an understanding of the problem, and to develop solutions to the problem. Information regarding methods of experimentation, (specific procedures) are available so that students can pursue a problem with as much self direction as possible. All the materials needed to carry out such activities are easily accessible to the student so that he does not need to consult the teacher in order to secure each item as needed.

References are available in the classroom which enable the student to learn how scientists have found answers to problems, but answers to problems which the student could discover through his own direct experience in the laboratory are not to be found. These references are on a wide vocabulary and reading level to meet the range of reading ability within the group, but have their content in keeping with the maturity level of 9th graders. References explaining laboratory techniques enable the student to adapt methods to the solution of his problems.

In each major area of study there would be enough activities on different levels of difficulty so that each student would have problems which would challenge his ability. These activities also provide for many different methods of learning, including experimentation, reading, preparing charts, models, mock-ups, displays, papers, and oral presentation.

Adequate pre-testing devices enable the teacher to discover both misconceptions, and depth of understanding of each student. The teacher will be able to extend and add depth of understanding for each student who is in advance of the group. This also provides for remedial help to those whose backgrounds are limited. Adequate tests for measuring growth in the understanding of principles, and their application to new situations aid the student in understanding his own knowledge and progress in areas he can see are important. These devices and the attitude of the teacher promote learning for meaning and for long-time understanding rather than for short term retention of facts.

The resources of the community are fully used to provide a direct relationship of science education with the activities and life of the community. Industries and scientists cooperate actively with the faculty.

In observing such a class over a period of a year, one would notice that the class would not "cover" as many areas of study as is now typical, but that there would be much greater emphasis in depth of understanding on the part of each student. The atmosphere of investigation would be evident in both teacher and students, and discussions of "how" and "why," and "how do we know what we know?" would predominate.

What then are the objectives of such a program? Certainly, the most prominent objectives are:

1. To develop and maintain an interest of science.
2. To develop an understanding feeling for science and scientists.
3. To develop an understanding of cause and effect relationship.
4. To develop a sympathy with science and an appreciation of the way scientists work.
5. To provide varied and continuous experiences in problem-solving.
6. To develop an understanding of the social and economic implications of science.
7. To develop an appreciation of the limitations of science.
8. To provide students with the opportunity to discover the wide variety of career possibilities in the field of science.
9. To develop an aesthetic appreciation of the orderliness of nature and natural laws.

To the class room teacher, the generalized strategy of objectives is sometimes difficult to translate into the day-by-day tactics of the classroom. We have noted that the objectives center on understanding science, but do not, as yet give us a clue as to what aspects of science.

The Southern Committee of the State Science Committee of the California Association of Secondary School Curriculum Coordinators submitted the following areas for study in the Junior High School Science Curricula:

A. Energy.
   1. Energy is important to life.
   2. Energy appears in many forms.
   3. Energy can be changed from one form to another.
   4. Industrial development is based on energy utilization.

B. Matter.
   1. Everything in the world is made up of one or more simple substances called elements.
   2. Matter has weight and occupies space.
   3. Matter is made of many small particles in constant motion.
   4. Matter and energy are interrelated.
   5. Many substances essential to our modern life are becoming exhausted.

C. Living Things.
   1. All living things are composed of cells.
   2. Living things carry on the same basic life processes.
   3. Living things are interdependent.
   4. All life depends directly or indirectly on the energy of the sun.
   5. Living things change and are changing.
   6. Survival of living things is dependent on adaptation.

D. The Universe.
   1. The universe is vast.
   2. The members of the universe are in constant motion.
   3. The basic laws of gravity and motion apply to all members of the universe.
   4. All the members of the known universe are made of one or more of the simple elements.
   5. Our solar system is a minute portion of the universe.
   6. Space travel is scientifically possible.
   7. Science has developed instruments for accurate measurement of the size and motion of the universe.

As one can see from the above list of concepts, the actual units of study remain to be developed. Brandwein [4] offers nine units of study from which the teacher and students would make their choices. In the New York State Science Sequence [9] ten units of study are suggested, including, Kinds of Living Things, Using Electricity, Common Chemical Changes, The Atmosphere, Rocks and Soil, Keeping Health, Survival of Living Things, Living and Moving Things, Energy from the Sun, and Earth and Sky. These suggested units are for grades 7–9, and are not structured by grade level. Criteria are offered for the selection of units by the school or teacher.

Selection of content will become more and more a problem for teachers, as further developments in science make it less possible to provide both a program which is modern and one which "surveys" the sciences. The following list of criteria for the selection of contents are adapted from the New York State Science Sequence [9], lectures by Dr. Paul DeH. Hurd, Stanford University, and the writer's opinions. That content should be selected which:

1. Offers many opportunities for problem-solving.
2. Includes a range of materials of sufficiently wide interest to be adaptable to the class.
3. Will make it possible for the more capable students to extend their understanding beyond that of the average.
4. Is more modern or is on the frontier of science.
5. Has the greatest potential for transferring to life situations.
6. Will enable students to have many direct individualized experiences.
7. Has a wide variety of teaching possibilities.
8. Has the greatest possibility for an integrative experience.
9. Is more related to the resources of the community.
10. Offers opportunities to meet as many objectives of the course as is practicable.
11. Anticipates the future needs of the students.
12. Contributes to a sequence of experiences which provides for growth from year to year.
13. Has the greatest human concern for most people.

In examining a description of more functional science programs, objectives of these programs, and some criteria by which content can be selected, one wonders why many schools do not develop newer and more effective curricula. The description of a program presented in this paper is

adequately supported by research, not only in the field of science education itself, but in the research in the nature of the learning process, and the developmental tasks of youth. An analysis of the kind of atmosphere which enables teachers to develop such programs may be of help.

Change in curriculum means more than revising a course of study, or setting up new objectives or criteria for the selection of content. It means more than adding new materials or devising new techniques. It means basically that there must be a change in the persons who control and are concerned with the curriculum. Burleson's [5] proposed systematic process of curriculum change can be viewed as having three interrelated phases: an analysis phase, a plan for action phase, and an execution phase. In each of these phases, those who are to do the actual teaching must actively participate. Pellett [10] found that in the Whittier Union High School District a number of environmental circumstances aided in the stimulation of science curriculum development. A few of these environmental factors noted were: dissatisfaction on the part of science teachers with one course of instruction; an administrative orientation which seeks to stimulate constructive change rather than to deter change; provision of time for department head supervision and coordinated services by district personnel; and the availability of the resources for intensive study of problems posed by the curriculum study, such as research studies, curriculum materials, and consultant help. Perhaps the most important ingredient for progress in this field is the administrative environment which encourages teachers to utilize their creativity and encourages new solutions to problems. This same environment then provides those new materials and facilities which enables teachers to implement a program without undue delay.

If a faculty accepts the program described as a desirable one, and the administrative atmosphere encourages the development of such a program for general science, then the details of group planning can begin to cope with the specific problems which need to be solved in order to inaugurate such a program. These problems are:

1. What kinds of classroom facilities will best provide for this program?
2. What kinds of permanent equipment should be available in the classroom?
3. What reference books should be in the classroom, and what references should be in the school library to supplement these?
4. What scientific journals and magazines should be available to the students? Teachers?
5. What resource units should be developed by the faculty for use in general science?
6. How can funds for purchase of special materials such as isotopes, etc. be provided so that these materials can be obtained without delay?

One can easily see that the development of answers to these questions will take the time of science teachers. Provision must be made by school districts for the allotment of time for teachers to develop better programs for their students. The present need is too great to wait for the gradual development of answers by the usual part time means. Two possible steps must be taken. Teachers might be released from one or more classes during the school year to undertake such a project, or they might be employed in the summer.

Answers to these problems are beyond the scope of this short paper. However, the writer believes that if the general outline of an idealized program can be agreed upon by professionals in the field, a major step toward the solutions of these problems is well underway.

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CREATIVITY: SOME ASPECTS AND IMPLICATIONS

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1. BACKGROUND AND STATEMENT OF THE PROBLEM

ONE of the major problems of American society today is the discovery and nurture of creative talent. A great deal has been written in the past decade, not only in the mass media, but increasingly in educational journals, about this problem. Much of the writing has only resulted in a further confusion of the meaning of the terms, "creativity," and "creative thinking."

The present concern for the improvement of quality in the educational product, especially in the sciences and mathematics, has been voiced by many individuals. Milton Eisenhower [10] stated "What is worrying all of us now is that, in general, the quality of teaching is declining, and we are painfully aware of shortages in mathematics, the sciences and technology at the level of creative scholarship." The current criticisms of education makes it imperative for educators to understand what is meant by "creative," and to determine the implications of our knowledge of the creative process for the improvement of education.

Societies in transition need a greater number of creative individuals than more stable societies. American society, with its rapidly expanding technology is placing more and more demand on innovation. Whyte [34], Rogers [20], and many others have pointed out that the trend to conformity so evident in our culture has an adverse affect on creative talent. They agree that the aura of conformity which pervades our society is a deterent to the creative process.

Brown [4] states that "It is recognized today that every individual possesses creative ability to a greater or lesser extent (degree) in every area of human expression." As early as 1928, Rugg [22] indicated that the realization that children have creative ability was an extremely important concept for the school.

Drevdahl and Cattell [9] in a study of 153 creative artists and writers found that

the creative group differed from the general population in being somewhat more intelligent.

In a study of creativity, one finds very quickly that comparisons are difficult because of different concepts of the term which are reflected in the literature. In this paper, we shall first examine the various definitions given the term; then investigate the methods used in studying the creative process; describe what is known about the creative process and the factors in creativity; discuss the educational implications of this knowledge, and mention some of the unsolved problems in the area of creativity.

2. DEFINITIONS OF CREATIVITY

Usage of the word "creative" and "creativity" ranges from an extreme of equating the meaning with "originality," to reserving the term to include the process which produced novel things or ideas which have been recognized by society, and have withstood the test of time as a measure of their validity.

Brown [4, p. 85] states that ". . . a test for creativeness is in terms of its producer; it is creative if it is original or an improvement of a past performance no matter how it compares with the production or performance of others." Vinake [30, p. 250] indicates that creative thinking is "The process of combining realistic thinking and imagination, . . ." Rogers [20, p. 251] gives prominence to the product of creation: "My definition, then, of the creative process is that it is the emergence in action of a novel relational product, growing out of the uniqueness of the individual on the one hand, and the materials, events, people, or circumstances of his life on the other."

Drevdahl [8, p. 4] gives one of the most complete definitions, which includes most of the ideas expressed by workers in the field: Creative thought is "goal directed, easily flexible, manipulations of knowledge (concepts, relationships, etc.) in a wide variety of novel or original ways." Perhaps a combination of the definitions of Drevdahl and Rogers would result in the kind of definition needed to give an inclusive, but concise meaning to the term.

3. METHODS OF STUDYING CREATIVITY

An analysis of research methods used to investigate the problem of creativity reported by Drevdahl [8] revealed the utilization of three methods. The historical-anecdotal approach, the introspection-personal report approach, and the test, or objective approach have been used. The latter type of investigation seems to have been the most neglected, although in the past decade, Guilford, Drevdahl, Cattell and Christensen have attempted to isolate factors involved in the creative personality and intellect.

4. THE CREATIVE PROCESS

A number of studies indicate that the creative process involves a series of experiences, which have been described by different writers as phases, elements, factors, or steps. There is general agreement as to these phases (as we shall refer to them) in the creative process, although some workers report a longer series than others.

Rossman [21] in studying inventors confirmed the theory that there are at least three phases of creative thought. "First, there is the period of preparation; then comes a time of 'incubation'; finally there is a sudden illumination or flash of insight." Murray [15] and Patrick [18] concur in the recognition of four phases of the creative process: "preparation," "incubation," "illumination," and verification" which were named as aspects of creative thinking by Wallas.[1]

Olsen [17], in summarizing a symposium held at the Industrial Research Institute held in 1953, identified three phases of the creative process. First he noted that there was a facility in recognizing disturbing

[1] Wallas, G., *The Art of Thought*, New York: Harcourt, Brace and Company, 1926.

elements, the "thorn in the side," or sensitivity to discontinuities in the environment; secondly, action was taken to do something about this disturbance. This phase was followed by "inspiration," the "leap into the dark," or development of new hypotheses. It is the last phases about which he feels the least is known.

Skinner [23], and many others have seemed to broaden the meaning of creativity to apply to a much more superficial level of application and interpretation. He states "the activity necessary in true appreciation may give us some creative experience," and that ". . . reading itself is a creative activity." This kind of use of the term has tended to confuse the nature, and perhaps even the usefulness of the term.

Most of the analyses of the creative process have been done by using the introspective-personal method in studying individuals who have demonstrated creative ability. Specific examples from different areas of creative activity illustrate the process in its most direct form.

Patrick [18] in studying creativity in poets describes the process in these words: "I have an idea in the back of my mind for a long time, sometimes a week or two. I don't think constantly about it, but it keeps coming back.

I may get an idea for a poem from something I see, which may be with me for a long time. For instance, I saw a nun leaning over a pool of flamingoes, and got the idea of both being in captivity. I was a whole year trying to write that. I knew that it would be a sonnet or lyric, but that was all."

Cowell [6, p. 235] reports a similar situation in the process of music creation.

> I had at times curious experiences of having glorious sounds leap unexpectedly into my mind—original melodies and complete harmonies such as I could not conjure forth at will, and exalted qualities of tone such as I had never heard nor before imagined. . . .

Woodworth [36, p. 818] reports how Helmholtz, described his methods of discovering new facts and principles in physics, and physiology.

> Often enough "Happy thoughts" crept quietly into my thinking without my suspecting their importance at first; and then it was often impossible later on to recall under what circumstances they had come; they were simply there and that was all I could say. Sometimes they arrived suddenly, without any effort on my part, like an inspiration. So far as my experience goes, they never came to a fatigued mind and never at the writing desk. It was necessary, first of all, that I should have turned my problem over on all sides to such an extent that I had all its angles and complexities "in my head" and could run through them freely without writing. To bring the matter to that point is usually impossible without long preliminary labor. Then, after the fatigue resulting from this labor had passed away, there must come an hour of complete physical freshness and quiet well-being, before the good ideas arrived. Often they were there in the morning when I awoke, but they especially liked to make their appearance while I was taking a walk.

In summarizing and synthesizing the basic phases in the creative process from these and other studies, the following series of events seem to occur.

1. The person must "saturate" himself with the specific media of his specialty, and have a broad and thorough understanding of it.

2. The person must be sensitive to discontinuities; must detect problems, and be bothered by them.

3. The person must take action to solve or explain the discontinuity or problem. In doing this he utilizes all his past experience, and further saturates himself in the specific field of inquiry.

4. The person "breaks-away" from the problem, and allows for a period of incubation. This period may last for only a short time, or may be very long. Patience is a necessary attribute of the creative worker. It is our feeling that during this time there is interaction of the conscious with the subconscious, wholly at the subconscious level, with a subsequent reorganization of experience. (This is suggested by Ghiselin and others.)

5. The person, at some point, receives a sudden flash of insight, or "illumination" which may be either a complete solution to the problem, or a partial one. At this point there may be interaction with all other phases at the conscious level. It might be hypothesized that "illumination" occurs when the subconscious reorganization reaches the point where its potential usefulness as a solution is forced into the conscious level of thought.

6. The person tests, works over and refines the creative product. This includes his own evaluation

of the product, as suggested by Rogers. The product must be satisfying to the producer. The basis of evaluation lies within himself [Rogers–20–, p. 255].

7. The creator must communicate his production to others. This may be only in writing, or by the preservation of the product. [Rogers–20, p. 256] states "He does not create in order to communicate, but once having created he desires to share this new aspect of himself-in-relation-to-his-environment with others."

It should be emphasized that this attempt to block out the creative process is done solely as a means of simplifying the process. These suggested phases do not apply to all creative thought, nor does creativity follow a lock-step pattern. One might better think of these phases as elements which seem to occur in many of those creative acts which have been studied, but that any may be omitted, and there is an interaction among all of them.

5. FACTORS IN CREATIVITY

Since the creative process, as described above, involves a series of complex phases which are more easily labeled than understood, attempts have been made to attack the problem at the objective level.

Ashby and Bassett [1] describe a new test of creative ability—the H and B Test, together with directions for administering and scoring. In using this test with 25 leucotomized patients, 25 normal controls, and 25 psychotic, non-leucotomized controls, significant differences between the normals and the two other groups were shown, but not between the recovered and the psychotic groups. The operation does not lower the score for creative ability.

Guilford, in addressing the American Psychological Association in 1950 on the subject "Creativity," suggested that the following factors seemed to bear on the problem.

1. Sensitivity to Problems: But how do people become sensitive to problems? Why are some more sensitive to problems—one or many—than others? Is such sensitivity an ability or a temperamental trait? These questions have not yet been investigated.
2. Fluency in Thinking up Ideas: It seems clear that "The person who is capable of producing a large number of ideas per unit of time, other things being equal, has a greater chance of having significant ideas." But what factors control fluency? Are some non-verbal?
3. Ideational Novelty: "The creative person has *novel* ideas," Tests to discover "the degree of novelty of which a person is capable, or which he habitually exhibits" need development.
4. Flexibility of Minds: "Charles Kettering one time commented . . . "that a person with engineering or scientific training had only half the probability of making an invention compared with others." His comment was that an inventor should be defined as "a fellow who doesn't take his education too seriously." By this Kettering meant that those who have the flexibility to move from hypothesis to hypothesis is more likely to be creative than those who take their "education (or knowledge) too seriously."
5. Analyzing Ability: But it becomes increasingly clear that this ability must be wedded to synthesizing ability. Guilford might have pointed out here that for centuries perceptive thinkers have suggested that analytical habits, especially when used for purposes of criticism, discourage creative thinking and action. Thus British and French scientists have often observed that much of German science has been excessively analytical and, concentrating on "the production of peppercorns," has missed the main roads leading to significant generalizations.
6. Synthesizing Ability: "From Gestalt psychology comes the idea that there may be a factor involving *reorganization* or *redefinition* of organized wholes. Many inventions have been in the nature of a transformation of an existing object into one of different design, function, or use. It may be that this activity involves a combination of flexibility, analysis, and synthesis. . . ."
7. Conceptual Capacity: "There is a possibility of a dimension of ability that has to do with the degree of *complexity* or of intricacy of conceptual structure of which the individual is capable. How many interrelated ideas can the person manipulate at the same time? . . . . Some individuals become confused readily; they can keep one or two items of structure delineated and properly related. Others have a higher resistance to confusion—a greater span of this type."
8. Evaluative Restraint: "Creative work that is to be realistic or accepted must be done under some degree of evaluative restraint. Too much restraint, of course, is fatal to the birth of new ideas. The selection of surviving ideas, however, requires some *evaluation*."
9. Motivational Factors: Interests, attitudes, and temperamental factors bear upon the motiva-

> tion to act creatively. "Hypotheses concerning these factors in connection with creative people might be fruitful starting points for factorial investigation." [2]

Wilson, Guilford and Christensen [32] attempted to measure individual differences in originality, as a factor of the process of creative thinking. They regarded originality as having three dimensions: "uncommon," "remote," and "clever." Five of their tests to measure originality had in common a single factor which they regarded as evidence for the potential fruitfulness for the measurement of individual differences in originality.

Drevdahl [8] in a study of some of the relationships between certain objectively measured intellectual and personality characteristics ratings of creativity in a population of advanced undergraduate and graduate students at the University of Nebraska, came to the following conclusions (p. 26):

> 1. Creative persons in this group appear to be superior to the non-creative person in their verbal facility, fluency, flexibility, and in their originality.
> 2. Creative persons in this group appear to be considerably more withdrawn and quiescent than non-creative persons. Creative artists were somewhat more radical and self-sufficient than creative scientists or non-creative persons in either the sciences or the arts.
> 3. Apart from its classification as creative or non-creative, the art group was more sensitive emotionally, more bohemian.
> 4. Individuality or non-conformity appear to be desirable for creativity.

Drevdahl and Cattell [9] used Cattell's 16 PF test in measuring personality factors in creative writers and artists. They found that the experimental population differed from the general population (significantly) in eleven out of sixteen personality characteristics. They found that the experimental population differed from the normal population in being somewhat more intelligent, emotionally mature (ego strength), dominant, adventurous, emotionally sensitive, bohemian (autia), radical, self-sufficient, and of a high ergic tension level. They were also less cyclothymic, surgent, and subject to group control. The experimental population was similar to a creative scientist population in ten of the sixteen factors measured by the 16 PF test (in preparation). They postulated from these studies that personality is more important than intelligence, but that creative persons are more intelligent than the general population.

Should further investigation confirm the above conclusions, possibilities for increasing the level of creativity would appear to be favorable in light of what is now known about personality development.

6. SOME IMPLICATIONS OF THE CREATIVE PROCESS FOR EDUCATION

If we accept the definition of creativity as proposed by Drevdahl and Rogers, and the phases of the creative process as proposed in this paper, then we must look rather carefully at some of the recent writings regarding creativity in the school. We feel that there seems to be a general oversimplification of creativity, and a tendency to label as "creative," any product which a child might produce, when he is allowed to do as he wishes. The dangers of such an approach are self-evident.

Taylor [25, p. 8] states that

> The essence of the modern movement in education is the idea of creative experience and its liberating effects on the individual. The modern movement is in fact a fundamental shift in attitude toward life itself. It refuses to accept the conventional forms in which life is presented to us and looks for fresh ways of interpreting facts, for new forms of art, of architecture, of scientific discovery, of literature, of society.

Experiences designed to utilize the curiosity and imagination of children will, most likely, in the long run foster creativity, but to label this as a creative act seems to be a misuse of the term.

Since originality has been demonstrated to be a factor in the creative process, the school should provide experiences which encourage original efforts on the part of

[2] Cowley, W. H., A Memorandum on Research Productivity, for the Fund for The Advancement of Education, Stanford University, 1953 (unpublished).

children. Creativity does not develop unless the individual is perceptive to problems, and discontinuities in the environment. The problem-solving approach, implied by Taylor would be effective in developing creative potential.

Rogers [2, p. 56] states that "From the very nature of the inner conditions of creativity it is clear that they cannot be forced, but must be permitted to emerge." He postulates two primary conditions which must be met in fostering creativity. First is the factor of "psychological safety." He suggests that this may be established by (1) accepting the individual as of unconditional worth; (2) providing a climate in which external evaluation is absent; (3) understanding empathetically—that is, understanding what another person feels and does from his point of view, with acceptance of him. The second factor is "psychological freedom" (p. 258), which is described by Rogers as complete freedom of *symbolic* expression, but not in behavioral expression.

Tumin [26] has very effectively examined some of the obstacles to Roger's proposals, pointing to the competitive rating for status and reward as marked by external criteria which are characteristic of our society, and the problem of one of Rogers' assumptions that under conditions of psychological safety, men will tend to the "good" as against the evil."

Nesbitt [16] indicates that creative teaching (does he mean teaching for creativity?) requires small classes and rich reading materials.

In a study of elementary school children at three grade levels, Atkins found [2] that children in the lower grades relied more on their own experiences in formulating hypotheses, while children in the upper grades depended more on authority. Lower grade children suggested more tests for their hypotheses than did upper grade children.

Olsen [17] suggested that we should provide a climate of inventiveness, devise tests to select the creative, and develop talented students in order to conserve our greatest natural resource, "natural resourcefulness" [p. 200].

It would seem from the data, that creativity cannot be taught as a process, but that by developing the factors of curiosity, originality, imagination, problem-solving ability, and providing a broad experiential background for children, one would have the best opportunity for producing creative individuals.

We feel that Mooney [14, p. 546] best summarizes the point of view which might lead to teaching methods which will foster creative thought. Although this statement was written with regard to science, we feel that it has much broader implications.

> Despite the evident creative character of scientific endeavor, scientists seem not to be generally aware of this basic quality in their work. When asked directly, they may quickly say that scientific work is creative work; yet, they have not thought through what this means for themselves or the training of others.
>
> This is evidenced in tendencies to take science as subject-matter product, neglecting science as an active human process; to fix attention on the scientific truths already formed, neglecting scientific truths as a continuing creation; to take objectivity as the contending opposite of subjectivity, neglecting the emergence of objectivity as subjectivity clarified; to oppose feeling to thinking, neglecting the integral development of feeling and thinking; to assume arbitrary separation of fact from value, neglecting the rooting of fact in value; to limit research training to teaching established methods of testing hypotheses, neglecting half of the research process which has to do with the derivation of hypotheses which are significant for testing; to think of students as means to the teaching of science, neglecting science as means to the teaching of students; to take knowledge as the sufficient goal, neglecting its transformation into wisdom.

Do not these statements have a broader application for education than the science field?

IN A "NUTSHELL"

That the process of creativity is an intricate problem should by now be obvious. However, from the studies and articles, we can now summarize some of the tentative leads which are now becoming evident in

unravelling the knot. We will group these data under the general headings of: the creative process; personality factors in creative persons, intellectual factors in creative persons, the conditions needed for creative thought, and the educational implications of these findings.

The creative process seems to be the area most explored. General agreement of the phases of preparation, incubation, illumination, and verification would not seem as valid now, in light of the suggestions of Murray, Olsen, and Rogers. However, these new suggestions need to be evaluated objectively.

Personality factors have received recent attention by Drevdahl, Cattell, Christensen, and Rogers. Tentatively, it would seem that the creative person does differ from the general population in being more non-conformist, individualistic, extensionable, able to toy with elements and concepts, dominant, introverted but bold, and more self-disciplined. Each of these factors needs further testing in order to establish their validity.

From the standpoint of intellectual factors, it would seem that adaptive flexibility, associational fluency, and originality would be worthy of further testing. Guilford's work in testing originality looks promising.

From the studies of creative persons it seems that the climate of inventiveness, time for individual experimentation and reflection, and a rich background of experiences are desirable. Whether these are necessary for creativity needs to be tested. Rogers suggests that psychological safety and freedom are necessary requisites for creative individuals, and suggests testable hypotheses to determine the validity of these ideas. Verification of these factors will have great implications on the educative process.

The schools can continue developing practices which have been fostered for other reasons—the problem-solving approach to learning. This approach has been validated for other reasons, but if adequate attention is given to the areas of incubation and illumination, creativity would be encouraged. Mooney, whose statements concerning approach were previously quoted [p. 15–16], offers ideas for the formulation of hypotheses regarding method which could be tested in the classroom. Such testing should be done. Weisskopf [31, pp. 187–8] questions the practice of many teachers who devote so much time to the process of preparation and verification, and completely omit the processes of incubation and illumination. She concluded her paper, as we will this one by stating "Just as we often deceive small children about the nature of biological creation, we often deceive older children by pretending that intellectual creation is unemotional. Thus by de-emotionalizing creation from youth, we suffocate intellectual creativity."

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A BRIEF LOOK AT THE HISTORY OF SCIENCE EDUCATION IN AMERICA: ITS PAST, PRESENT, AND FUTURE

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No one can deny that science, as it has developed throughout the ages, has become a major force in the world carrying with it impacts and implications of great magnitude. Scientific progress in America has grown by leaps and bounds. Regardless of the criticism launched against science education in our nation's schools, we must give credit in part at least, to the role that science education has played in this progress. Scientific achievement is now reaching the point where it is moving forward in terms of geometric progression and hence, much consideration is now being given to science education in order that science courses in the schools may more effectively prepare students for life in the science dominated world of the future.

Scientific development, to a considerable extent, has flourished in only comparatively recent times from the historical point of view. There has been much discussion and

varied opinions as to when the age of science really began. In this regard, Wells has said,

> In the year 1543 appeared a work entitled, "De Humani Corporis Fabrica" (The Structure of the Human Body), by the Belgian anatomist, Vesalius. His publication, contradictory to the word of Galen, yet indisputably proved, marked the overthrow of dogmatic authority, and paved the way for the scientific renaissance. In rapid succession, one discovery after another was made public as the world entered upon what has become the "Age of Science." [1]

In spite of the fact that the American science education program was slow to establish a rightful place in the schools, its importance was none-the-less early but limitedly recognized in our history. This has been pointed out by Bowman who noted that,

> Thomas Jefferson, himself a scientist, saw the value of a scientific education to a democracy and he "coupled freedom and science as conditions of progress." [2]

From the period of the discovery of America in 1492 until about the year 1635, there was virtually no science education at all in the schools. Schools were dominated by religious emphasis, directly and indirectly, and the curriculum was rather limited. Science education during the next hundred years was still quite limited, poorly organized, and little emphasized.

During this century two types of schools became rather well established. One of these was the Latin Grammar School, first organized in the New England states, whose primary purpose was to teach Latin—a carry-over from the Ciceronian classical education tradition of Europe and England. These schools functioned more or less in the same manner and capacity as what we now call the junior high school. There were no schools which could be said to compare to our modern high school. The curriculum of the Latin Grammar school made no provision for science and science was therefore not offered to students.

The second type of school found in America during this period was the University though not great in number by comparison. Probably Harvard and Yale were the leading schools of this nature at this time. These schools did present some science however, and thus it can be said that formalized science education as such had its beginnings at the university level in the United States. None of the universities however, made provision for a student to major in science since none offered science as a major subject. Most of the educational opportunities provided again followed the patterns set down by the educationai patterns of Europe. The science which was offered consisted mainly of three courses. One of these courses, surveying, was presented as an outgrowth of a national need—that of an expanding population settling new parts of the country which needed land surveyed. Another course which was offered was that of astronomy. Its reason for inclusure was probably because of its general interest. Some of the colleges offered a course in natural history which was limited to senior year students. In all cases there was no laboratory work given or required.

From about the year 1750 to 1850 the industrial and technological age had its beginning in the United States. The first factory was established in Rhode Island by Samuel Slater in 1790. The Embargo Act of 1807 really first stimulated industrial development since American goods were in demand. But it was the War of 1812 which proved to be of utmost importance since it had the direct effect of cutting America off from the flow of goods from British factories. This resulted in rapid industrial changes which saw transportation networks develop, urban areas to rise, factories to spread and the like. By the year 1890, it was clear that industrialism based upon national need and scientific progress had become dominant in American society.

During this period there were changes in the schools with respect to science educa-

[1] Harrington Wells, "Science and Religion in Education," *Science Education,* Vol. 26, No. 2, February, 1942, p. 96.

[2] Bowman, *Science,* December 6, 1935.

tion. These changes were minor ones however.

The Latin Grammar School remained as did the university. Never-the-less there was a new educational development, the establishment of the Academy. The Academy filled the gap between the Latin Grammar school and the University and it functioned in much the same purpose as the high school or secondary school today. Unfortunately it was intended to serve the needs of only those individuals who were going on to college and its orientation was in this direction. By this time some science courses had made their way into the Academy and such courses as biology types of courses were taught but were for the most part largely descriptive in nature. These types of courses were taught with great religious emphasis. Some astronomy and some geology was offered but only for a period of about eight weeks out of each year. A course called physical geography was presented and relegated to the classification of science education. Some Academies offered a course in chemistry but this was largely descriptive and has been referred to as household chemistry. Again, no provision was made for laboratory work and it was considered of little value with no place in the school.

It is interesting to note that while science education was beginning to get a foothold in the Academy, it was having a struggle to stay alive in the institutions where it originated—namely, the university. Astronomy was emerging as the strongest and most important of the sciences in the university while at the same time most of the other science courses were rather looked down upon and regarded as not respectable. In general, the science education that was done during this period was done at the home of the professor who furnished his own scientific equipment and set-up his own demonstration experiments. The University divisions or departments of science were often located in buildings away from the main campus or at its border and the name of the university was not permitted to be used in connection with it. It is here that many of the Institutions of Science found their beginnings.

The fifty years that followed this period saw the Academy grow into the high school as we know it. And as the nation grew and prospered so did the cause of science education. The colleges began to establish prescribed curriculum requirements. With the increase in industrialism and the need for more and better farming techniques the Agricultural and Mechanical Colleges formed to meet the need.

By this time, more sciences were added to the high school curriculum most of which were one semester long. In spite of the increase in science course offerings there was still no provision made for using laboratory work and all courses were taught without it even in the colleges. In the year 1865 however, laboratory work was finally introduced into the emerging scheme of science education. This first science course to use in the classroom laboratory work was at the high school level and was a course in chemistry for girls only. About five or ten years later this use of laboratory work finally expanded into boy's classes as well. Eventually laboratory work dominated the course and some laboratory periods were three hours in length. At this time there began to be placed increasing importance on the use of laboratory notebooks some of which were very elaborately prepared with beautiful drawings and very careful lettering. Their importance grew to the point where they became an important criteria for college entrance. This was further encouraged by college entrance requirements and some schools, like Harvard, required that a prescribed 40 experiments be done and the results recorded in a notebook to be submitted by each student as one important basis for evaluation in determining whether or not the student should be allowed entrance into college.

In the year 1894, a group of high school science teachers met at a convention. They

suggested that some coordination in the sciences be established. This resulted in some change in thinking and the start of at least some cooperative effort in science education at the professional level. The elementary school in the meantime was just beginning to introduce science into the curriculum though admittedly on a rather limited basis. While there was no physical science presented there was some nature study the purpose of which was primarily to develop aesthetic ideas in young children.

During the period from 1900 to 1915 mechanization began to get a good start in the United States and such things as steam power, mining, oil production, radio, and the like were coming into prominence. The development of all these things meant that more and more trained workers were needed and as a result, a number of additional universities were founded. High School science courses began to grow and there was considerable experimentation with types of courses. High school enrollments grew and the place of science in the high school became firmly established. Botany and zoology were fused into a course which was generally called civic biology. This union has persisted in the high schools even to present times though sometimes called life science or some other comparable term instead of biology. From the point of view of science education this was a significant move in that it pointed to the recognition of the interrelationships of at least the different life sciences. In the early 1900's the high school physics course was one which emphasized the principles of physics through the use of many types of toys since it was felt that the operation of certain selected toys demonstrated the principles of physics. This led to a period which was generally referred to as toy physics. About the year 1910 the extensive use of toys was dropped from the physics course. During this period the course called physical geography was dropped from the science curriculum although today a similar course is making its way into the high school science program under the general name of mineral science. Geologists have long felt that this area of science has been too much neglected. Even today, it is more likely than not found to occupy but a small segment of the general science course. In addition to general chemistry, a chemistry course for girls developed under the title of household chemistry. Its general function was related to homemaking and cooking. It was also during this period that the high school's most popular science course was established—that of general science. It has remained even up to the present the most popular science course. This is probably partially due to the fact that until very recent times most high school graduates did not continue their formal education beyond the high school level. Further, it was during this period that the idea of the skilled worker was developed in America. The construction and operation of factories grew and with it concern for safety. Many safety movements began.

In the period from 1915 to 1940 the beginning of the next big industrial age took place. Such things as the radio, electrical appliances, farm equipment, automobiles and such, began to come into common usage. Since science and industrialism was rapidly expanding it was only natural that science courses should likewise expand particularly in the direction of helping people become more scientifically literate. Bossard says that,

> The first science orientation course to be offered in American colleges was that at Brown University in 1915–1916.[3]

The first course of the survey type to receive wide recognition, however, was that formulated in the University of Chicago in 1923–1924. This course was organized by H. H. Newman[4] who, with some of the others on the University of Chicago faculty,

[3] James H. S. Bossard, *Man and His World* (New York: Harper and Brothers, 1932), p. 92.

[4] H. H. Newman, "An Orientation Course," *Journal of Higher Educ.*, 2:121–126, 1931.

wrote the first textbook for courses in generalized science, entitled *The Nature of the World and of Man.*

This was a trying period in the nation's history. There was a period of inflation in the 1920's followed by some ten years of economic depression. In high school, the general science course which was started in 1915 spread to the eighth grade and eventually to the seventh grade as industrialization continued. In the elementary school the nature study program was replaced by elementary general science about 1928 to 1930. The general science movement was well established by the 1930's and had also found its way into the college. Willis J. Bray gives evidence of this spread in an address delivered before the faculty of the Northeast Missorui State Teachers College in Kirksville, Missouri, on October 4, 1938. In this address he said.

> This college has been actively interested in the general education movement for more than four years, during which time we have been experimenting with this very important field of work. Most of the divisions of instruction have been busy studying the contribution which their respective fields might make to the program of general education. The Science Division was among the first to begin such a study in 1934. We have been studying and evaluating subject matter in the light of the objectives of general education in an effort to build a course of study that will make a maximum contribution to this field.
>
> The first course presented in this division in the general education field was organized and taught by Dr. John Harty, then of our Physics Department.[5]

Further indication of the felt importance of generalized science in this period may be seen in a statement by Charles W. Reynolds who said,

> Generalized science has had an extensive period of development within the last ten years (1928–1938). This movement seems to be gaining momentum with increasing acceleration.
>
> This general education movement has spread from single institutions to entire state systems. In every state which has state teachers colleges, survey science is offered in one or more schools.[6]

Since many people felt that science was responsible for the development of machines and that machines had caused unemployment which resulted in the depression, there was considerable public reaction against science and scientists. This was particularly true in the 1930's. Some large industries however, began to see the impact and importance of science and for the first time set-up departments of research. It was not long until high school graduation was almost a requirement for a job instead of mere completion of an eighth grade education as had previously been the case. More and more students were going to school. One result of the latter was the development of the Progressive Education method. It was designed for the purpose of obtaining a program which would fit courses to a wide range of abilities considering individual differences in students. Probably the two most important factors causing great increases in enrollments during this time were the child labor laws and the compulsory education laws. By the year 1940 there was a great questioning of science. During the next ten years there was a slight recession in science in the United States. This was likely due to the hold-over of the idea that science was in some way directly responsible for the economic depression of the 1930's. Bray's statement seems to indicate the felt role of science at this time when he further commented that,

> Industry today is dominated and controlled by chemistry and physics.[7]

It was also during this time that the now famous Harvard Report [8] was published

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[5] Willis J. Bray, "Science in General Education," *Science Education,* Vol. 23, No. 1, January, 1939, p. 59.

[6] Charles W. Reynolds, "The Development of Generalized Science Courses in State Teachers Colleges," *Science Education,* Vol. 24, No. 2, February, 1940, p. 88.

[7] Bray, *loc. cit.*

[8] Harvard Committee, *General Education in a Free Society* (Cambridge, Massachusetts: The Harvard University Press, 1945).

which emphasized science as a field of study, gave importance to scientific thinking and indicated that many of the concepts of science should be incorporated in teaching. While the report was intended to apply to the high school level it had great influence at the college level.

The period since 1950 probably represents the biggest turning point in scientific progress. It has been a time when real importance has been placed on education and the idea that education extends throughout all life has gained favor. We are finding ourselves confronted with a shortage of scientists and science teachers—a shortage that is affecting our economy. It is appearing that out present social conduct and rather traditional ways of thinking are adapted far too slowly to keep in step with changing technological trends and the needs and problems they create. In spite of efforts to improve the science curriculum there has been continued criticism of the science program particularly at the secondary level.

> To be sure, science offerings have improved remarkedly in the past few years, but one has only to visit local schools to discover how woefully inadequate our science instruction is in training youth to think.[9]

Further, the advent of the atomic bomb and the space satellite has brought to the pulpit, dinner table, and backyard fence, discussions of science involving generalizations vaguely made and sometimes wide-eyed ignorance. Increased interest has in itself created a need for change. In a study conducted by the University of Illinois,[10] which was under the direction of J. Harlan Shores, professor of education, the interest of children in science was considered. The nation-wide survey included 6,313 pupils in grades four through eight, 4,531 parents, 212 teachers, and 169 librarians. Some of the survey findings indicated that parents and teachers underestimated children's interest in animals; that children ask more questions about science than any other subject; and, that at the library, grade school children are looking up information about science more than information in any other field or subject. But even with the ever-increasing interest in science, many people shy away from the traditional science program courses. Thus it would appear that somewhere in the historical development of science education we have somehow failed to anticipate the future and prepare accordingly for it.

As stated earlier, probably one of the most significant developments as far as the life sciences were concerned was the fusion of zoology and botany into the unified biology course. The historical development of this type of fusion has recently reached into the physical sciences and a fusion of the same nature had begun shortly before 1950. A post card inquiry, for example, sent to 357 cities of over 25,000 population in forty-two states and the District of Columbia showed that a total of fifty-four cities or 21.6 per cent were offering a fused physical science course in at least one high school.[11] It would appear that the most striking historical trend in recent contemporary science education has been towards the adoption of a physical science course in the secondary school.

> There is every reason to believe that the high school physical science course has come to stay, as a part of a sequence which begins with elementary science, and extends through general science and general biology. Doubtless the future will see more general agreement as to what the content and emphasis of this relatively new course should be; in fact, its very existence opens new and inviting avenues for research in science education.[12]

[9] Fred E. Ellis, "Improvements in Teaching of Science," *Clearing House,* Vol. 19, February, 1950.

[10] J. Harlan Shores, "Children in Science," *Science Digest,* August, 1955, p. 32.

[11] C. R. Watson, "A Comparison of the Growth of Survey Courses in Physical Sciences in High Schools and Colleges," *Science Education,* 24:14–20, January, 1950.

[12] Earl J. McGrath, *Science in General Education* (Dubuque, Iowa: W. C. Brown Company, 1951 ed.), p. 375.

Certainly McGrath's prophecy is coming true for only during the past few years an effort was made on a large scale to establish a curricular content for such a course. This was, and is being done at present, by a committee known as the Massachusetts Institute of Technology Physical Science Study Committee working under a large grant from the National Science Foundation.

As has been discussed earlier, science has played an outstanding role in everyday life particularly in recent years and is now changing daily existence in such important aspects as transportation, health, communication and power. The social, economic, and political implications are both national and international in character. Obviously, we are launched upon a space age, a power age, and an atomic age, where boys and girls alike are literally forced to be concerned with some of the principles of science and their ever-important applications in modern living. This applies to all youth everywhere. All are vitally affected by science in many ways. Science education must share in the responsibility and the task of preparing them to be able to live effectively and happily in an ever-increasingly complex, technological world and to intelligently face the vast problems with which they will be confronted.

To say the people of the world live in an age of science is to say little. It is truly an age of more than science. It is a time when science and society must work together toward mutual cooperation in solving the complex science orientated problems that face us now and those which lie in the uncertain future. Not only for society but for education as well, it is a time of crisis. With the advance of scientific living, new problems and needs are not only created but they must be resolved effectively and to the mutual benefit of every member of society. Therefore, it becomes necessary for the school to determine what the role of science and science education should be in order to meet these problems and needs.

Some, in our society, will be the producers of science but *all* will be users. In this regard McNerney points out a two-fold purpose of the science curriculum:

1. To select, through proper guidance, those interested in, and capable of, production.
2. To make the users more intelligent and appreciative of the method of science, the wonders of the natural world, and the products of modern science.[13]

Therefore, the science curriculum will likely point more perhaps, towards general education and socially directed aims with greater emphasis upon aspects of consumer science and vocational science. The basic assumption of science is in actuality one of order and complete interrelation. Thus the science program needs to emphasize its relation to society and other fields of knowledge in a *balanced* and *integrated* way.

The highly rapid progress of science is bringing about earth-shaking changes on society and as a result, upon the needs of individuals in the society. Oliphant has said,

> No historical event of the past has influenced the world and the lives of men as has the progress of science in the past century.[14]

He also states that the stature of man has greatly increased under the influence of advancing knowledge and science is emerging as the greatest cultural influence of all time.

With the overwhelming increase of scientific products and knowledge there is becoming more and more need for science and society to collaborate in utilizing these advances for the benefit of all mankind. Societal needs call for the controlling and directing of the products of science and the forces of nature into peaceful and productive channels. Society is struggling for world-wide solutions to tensions and an ultimate goal of world peace,

[13] Chester T. McNerney, *The Curriculum*, (New York: McGraw-Hill Book Company, Inc., 1953), p. 187.

[14] M. L. Oliphant, *The History of Science* (Glencoe, Illinois: The Free Press, 1951), pp. 175–76.

that to bring democratic social living within the sphere of the school is a major aim of all concerned and that science and science teachers are not isolated in this regard; rather the opposite, since their place is in the vanguard of social understanding because of the vital immediate impact and future potential of science in terms of society.[15]

Science, science education, and society need to profit from the mistakes of the past. To this end, science in particular is coming of age. Science has played a part in the history of the past and will likely play an even greater role in the history of the future. There appears to be an increasing necessity to better relate science to society and the world. There is added emphasis to place science in its "true" perspective, a point which is repeatedly seen, argued and discussed. James B. Conant points out that "the attitude of society towards science may be basically caused by fear but its manifestations ramify in many directions and appear in surprising ways." [16]

So important is the role of science in society that McGrath has been led to state that "much of the welfare of civilization, and perhaps even its fate, depends on science." [17]

Certainly the school science program from the college level downward will assume in the future more social responsibility by providing in the school enough understanding of the place of science in our culture to enable the majority, who will not be actively engaged in scientific pursuits, to collaborate intelligently with those who are and to be able to criticize or appreciate the role and impact of science on society.

There is also the need to strive for even greater societal scientific literacy among our people as a group and to more adequately train those individuals who will eventually become the scientists and leaders of America. The United States President's Scientific Research Board revealed in a policy statement that,

As a people, our strength has lain in the practical applications of scientific principles rather than in original discoveries and that in the past, our country has made less than its proportionate share in contribution to the progress of basic science.[18]

The Board further points out that the free exchange of ideas which formerly permitted us to import to meet our needs no longer prevails and that the unity of western civilization has been shattered. For the first time in our history we appear to be on our own as far as the extension of knowledge is concerned. Many current public announcements support this view. This too, will in part affect the direction that science education will take. Thus, if science education is to serve our people and our nation it must be alert to the needs of both, not only in terms of the past and present, but particularly in terms of the anticipated future. It is interesting to note the correlation between a major scientific change and the creation of educational and social problems which follow. One has only to examine the past to see this relationship. The Industrial Revolution, for example, produced problems of mass production, transportation, and the like. A similar pattern but on a much larger scale is emerging as a result of the development of atomic power. Every major scientific achievement has produced countless new problems and difficulties regardless of their potential good. We, as a nation, have never been socially or educationally prepared for a major scientific change in advance of the change. This should be a major concern of science education now and in the future. Simply understanding science is not enough. Sigerist [19] feels that aside from an under-

[15] Harrington Wells, *Secondary Science Education* (New York: McGraw-Hill Book Company, 1952), p. 20.

[16] James B. Conant, *Modern Science and Modern Man* (New York: Columbia University Press, 1952), p. 6.

[17] McGrath, *op. cit.*, p. 1.

[18] John R. Steelman, Chairman, United States President's Scientific Research Board, *Science and Public Policy* (Washington, D.C.: Government Printing Office, 1947), p. 5.

[19] Henry E. Sigerist, The History of Science in Post War Education," *Science*, 100:415–420, No. 10, 1944.

standing of science there must be training in methods of historical and scientific research as well, which would permit background for evaluating and interpreting historical sources and events. It is also interesting to note in this regard that a study of 107 colleges and universities indicated that 58 "did not include in their curriculum, in any form whatever, a course directly or indirectly connected with the teaching of the History of Science." [20]

It seems obvious that the role of science education in the future will likely be even more important than its past role. Harrington Wells supports this point and has stated, "There are two hopes for mankind: religion and science." [21]

The world of the present and future will see almost undreamed of changes. We are living in truly a "new" world requiring new approaches and new techniques in science education. These new creative approaches should apply to all other areas of learning as well. What these new ideas will be and how they will be applied remains largely unanswered. The role of science will be a dominant one since there is no descriptive term of this age which can be used that does not give predominance to science. Modern living means that we have and use new kinds of things all of which involve science or the products of science. There can be few economic issues discussed without in some way involving science or engineering. Many of our currently great political issues are really scientific ones.

It becomes increasingly evident therefore, that science education in all its aspects will have a strategic position in our nation's coming history. Our citizens must learn how to define objectively, investigate, analyze, correlate and describe not only the social issues and conditions of our society but equally important, they must learn how to objectively and factually appraise morally and practically the uses of science. Science therefore, holds a rightful place in the schools of our nation. Its potentialities and possibilities for social good, as yet but faintly realized, can only be made clear and challenging by education to that very end. The responsibility of science education in the scheme of our country's future is paramount, for actual survival may be at stake.

[20] R. H. Simmons, "The History and Philosophy of Science: A Challenge to Higher Education," *Science Education,* Vol. 41, No. 1, February, 1957, p. 60.

[21] Wells, *op. cit.,* p. 97.

HIGH SCHOOL BIOLOGY: ITS CONTRIBUTIONS TO HEALTH EDUCATION

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Since many aspects of health and health education are scientific in their nature, many desirable health habits can be promoted in the high school biology class. The biology course must do two things: (1) provide the student with factual knowledge so that he may intelligently react to the maze of mis-used scientific information encountered by our population every day, and (2) develop within the student an awareness and proper attitude towards personal and community health problems of the present and future [1].

That the modern society is still lacking in the above requirements is clear. In referring to its most serious communical disease, the Arizona Department of Health Annual Report for 1953–54 states, "The lack of knowledge on the part of the citizens regarding tuberculosis is one obstacle in tuberculosis control" [2]. Even when the facts are known it is easy to believe some

of the twisted information found in our society. Strong anti-intellectual attitudes, combined with patriotic appeals, can force entire communities to abandon scientifically sound health projects such as fluoridation of public water supplies [3]. And consider the confusion created by the Salk vaccine for polio [4].

Adolescents are concerned with many problems closely related to those topics usually included in a study of biology [5]. They want to know about diet and their skin conditions, diseases both pathogenic and hereditary, similarities and variabilities within their own age groups, and the mysteries of adolescent growth and sexual maturity. Biology can and should supply the information to help adolescents understand those problems peculiar to their own stage of development, and at the same time encourage the proper attitude towards these problems.

What health facts should a high school biology course provide? The minimum essentials must include accurate information about nutrition, drugs and their affects, diseases, immunity and allergy, heredity, growth, reproduction, and the affects and interrelationships of environment on all of the above [6]. A study of these aspects of biology cannot help but lead to the development of various attitudes towards personal and community health problems. The social implications may be very great.

The development of specific attitudes should parallel the subjects listed above. These attitudes are as follows:

1. Good health can be maintained only when a proper diet is selected by the individual.
2. Drugs used without a doctor's advice may cause permanent damage or death, and alcohol or tobacco may cause physical damage if used indiscriminately [7].
3. Diseases have definite causes, and many can be prevented, eliminated, or reduced in severity by simple control measures such as sanitation, isolation, and immunization.
4. Both similarity and variability are normal aspects of life, and there are certain laws of inheritance which are relatively stable.
5. Growth is a normal process of all living things and follows a regular pattern, being primarily influenced by heredity and environment [8].
6. All living things, including man, have a definite life cycle [9].
7. No one organism is better or worse than the other; it is merely different and is a part of the physical and biological environment. Man is a very important part of this environment, and must therefore assume considerable responsibility in living with and in it.

Having acquired a desirable background of facts and attitudes, the student should be made aware of the more recent national and local health problems. What are the harmful effects of smog [10]? Does smoking really cause lung cancer [11, 12]? Should the Salk vaccine continue to be used or should the public wait for a safer form to be developed [4]? And how serious are the biological dangers of radioactive materials [13]? All of these are current health problems being faced by our adult population and already affecting our adolescents. We must provide young people with the knowledge to satisfactorily solve these and future problems for themselves.

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SO YOU'RE GOING TO TEACH PHYSICS: FROM AN OLDER PHYSICS TEACHER TO A YOUNGER, PROSPECTIVE ONE

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So you're going to teach physics? Don't, unless you plan to devote practically all of your time and energy and attention to it.

But do you have in mind an occupation that you consider to be more worthwhile? Maybe it is, but just be sure that you are not seeking worldly pleasure, prestige, or profit thereby. Other jobs are necessary, too, and have their problems. Whatever you do, be sure that you clear the household of your mind and understand your motives. After all, what is important is not just what you do but the underlying motive for what you do, how well you expect to do the job, and the bad motives and the bad jobs that you forsake to do what you do.

If you stick to physics teaching, you will find that you are in a minority. In all probability, your rights will not be respected. You are, however, in a class with many worthy ones. You have so much to do when you are teaching that you do not have time to defend your rights. If you can survive, and many have survived before you, you may realize that many others have chosen obligations ahead of rights and do not object to being servants of the people. Some who could teach physics take jobs that they consider less harassing and more financially remunerative. These jobs may be quite monotonous and devoid of objectives as high as those of teaching physics.

If you like pupils of high school age, have good health, have the ability to teach physics, have a spirit of inquiry into unknown physical phenomena, and are at home in a physics laboratory, you will find satisfactions in teaching high school physics. There will rarely be a day at the close of which you will not have a wholesomeness of feeling and the same kind of thought that one has when he sings "When You Come to the End of a Perfect Day." Too, you will be going in the direction in which you are needed. There will not be a crowd going the same way. For not many people have the patience and the diligence to learn and to teach physics and, most important of all, the will to teach it. So go ahead and develop the patience and the diligence and the will to learn and to teach physics.

What are some of the problems of the high school physics teacher? Physics teachers in high school have assigned to them one or more extracurricular activities which keep them busy and which quite often take time from activities directly related to physics teaching. These extracurricular activities may be homeroom section, college bureau, intelligence testing, admissions, student council, science club, physics club, radio club, photography club, and so on. Such assignments may be made at the time when the teacher is a beginning teacher or a teacher new to a school. These extracurricular activities have been gradually added to the load of the high school teacher over a period of years. I hope that by the time you become a physics teacher the schools will be on a more even keel and those jobs inside the school of more trivial educational consequence will have been eliminated and those jobs that are more in keeping with other agencies will have been relegated to those to which they belong.

Physics teachers undergo pressures. On one side of the fence some of the engineers, scientists, and pupils who are particularly keen about science and engineering try to encourage physics teachers to make the course in physics more technical and mathematical; on the other side of the fence some of the administrators, supervisors, and

pupils who have weak backgrounds in mathematics and science try to encourage physics teachers to make the course less technical and mathematical. The groups of pupils who want either the more technical and mathematical or the less technical and mathematical may actually make up small percentages of the entire physics enrollment. Individual attention given by the teacher to these pupils is good to a certain degree and, by all means, the more gifted should be encouraged to develop scientific initiative, creativeness, and self-reliance but at the same time these gifted ones should understand that their minds are intrusted to them by God and that they are to use them for good, unselfish purposes.

Even if physics teachers did not have extracurricular duties and if the pupils who are supposed to be taking physics were taking it, the teaching loads of physics teachers would still be heavy. The teaching loads may be heavy because of the number of pupils, the number of different daily preparations that the teachers must make, the changes in textbooks and curricula. Time and energy of physics teachers are required to adjust methods to changes in types of pupils taking the course, to do library work with reference to the new trends in psychology and the new methods of teaching as well as the new developments in physics, to take inventory, to check over new and repair old apparatus, to set up demonstrations and laboratory apparatus, to collect visual aids, to make lesson plans, to attend scientific conventions, to visit scientific exhibits, to type, cut, run the mimeographing machine and do the other necessary clerical jobs, to correct tests, note books, and other papers.

One reason that physics teaching requires painstaking labor arises out of the necessity for the maintenance of physics apparatus. A physics classroom, laboratory, and storeroom are like a small household. When a physics teacher is new to a school or moves from one school to another, not only is there a need for an adjustment to the different school personnel and methods but also to the new demonstration and laboratory apparatus. If every school had an inventory of apparatus, being new to a school or moving from one school to another would not be such a hardship to the physics teacher. The physics teacher must become accustomed to the alternating and direct current, gas, water supplies and the care of them. Blueprints may or may not be missing. Sometimes apparatus is located in widely scattered storerooms at a distance half the school building away from the physics classroom. Many different groupings of pupils, such as those studying different courses or topics in physics and working at different speeds may be taught in the same room during the day. Then it becomes necessary for the physics teacher to mount and dismount hurriedly many different sets of demonstrations. The apparatus must be kept between classes in good working order with pupils coming and going during the day. Natural curiosity prompts pupils to handle apparatus. Thus the organization for many and the individualization of instruction come into conflict. At one time there may be so many pupils in the physics laboratory that they and the big pieces of apparatus with which they are working occupy too much space for the room.

Physics teachers do not have to move from one school to another to find it necessary to adjust to radical changes. There may be changes in school policy that relate to the organization of physics. Physics may have been a two-semester course of seven periods per semester and be reduced to a two-semester course of five periods per semester. This means a loss of twenty-eight per cent of the time per pupil devoted to the subject of physics as a whole while the pupil is under the supervision of the teacher. Different physics teachers may react to such a crisis in sundry ways. There may be a decrease in the total number of laboratory experiments or there may be a decrease in the total number of

observational trials for one individual experiment; there may be a replacement of the write-up of the entire laboratory experiment by the fill-in type; there may be an introduction of entirely new methods that appear to serve the purpose; there may be a combination of any and/or all of these changes. With such a decrease in periods for one group of pupils there remain periods in which the physics teacher may teach other pupils. The sum and substance of a change like this is that the physics teacher must maintain or improve the quality of instruction and at the same time extend instruction to a greater number. At least, the physics teacher tries to do what is humanly possible and asks for Divine assistance. A loss of time in physics per pupil does not obtain in all localities throughout the country. But everywhere in the country there has been during the past fifteen years an approximate gain of ten per cent in the subject matter of physics. Electronics and nucleonics have brought about a great influx of subject matter but there have been developments in many other fields of physics also. Adjustment to this new subject matter must be made.

Physics teachers like to be a little civic-minded, too, and to feel that, when it comes their turn, they should do their share in attending meetings of teacher groups and, on occasion, be representatives of teachers. You should get yourself into the proper frame of mind for this, too.

Physics teachers today have to serve as liaison agents to link outside organizations with the school. They must bring to the attention of physics pupils the physics contests that are available in many places. Some of these are the search for science talent scholarships, school and community and national science fairs, competition of teams in physics tests, examinations in physics for scholarships, summertime employment and research experience in physics in a laboratory or college. Physics teachers must encourage or discourage pupils with reference to these contests, they must select pupils whom they consider to be worthy candidates, they must write recommendations for pupils.

The topic of fairs and contests in schools should be evaluated and consideration given to the topic of fairs and contests in general and to each fair and contest in particular in which pupils participate. Science fairs and contests offer incentive and reward to pupils but it may be possible that the emphasis is on the basis of a short-term educational gain at a sacrifice of a long-term one. Some of these take so much energy of the participating pupils that their health may be impaired and so much time that little time may remain for their cultural training in the "best that has been thought and said and done." The fairness in the administration of these fairs and contests, the time taken by all parties inside and outside the school who are necessary to keep them going, the effects of fairs and contests upon the teachers in the school other than the science teachers, upon those pupils who do not enter and upon those who do enter and lose are some of the factors that should be studied. Also the degree to which people like contests and are motivated thereby, the development of an esprit de corps of the winning group or winning school as well as the morale and the self-confidence of the winning pupils, and the impetus toward a scientific career that a winning pupil receives and the field of study that winners and losers may have entered had there been no science fair or contest, should be studied.

A factor that makes the teaching of any subject in high school today so difficult and at the same time interesting is that in a democracy so many people are involved and are impelled in many different directions one moment and the next moment in just as many more directions. Our communication and transportation are so rapid that the changing modes and fads are almost immediately transferable to many. The eternal flux makes life more chaotic, people make more decisions than ever before and

change them, and the public school gets more of the impact of these differences and vacillations than any other agency does. In particular reference to science education an educational study made recently concluded that there is less agreement as to the purposes and methods of science in education than ever before.

What are some of the current ideas concerning science teaching today? One idea is that subject matter should be organized on the unit plan. Morrison, who was the creator of this idea, thought that physics was already organized this way. There are some who seem interested in digging into physics as it is and changing it along some other units. Such a change might result in some growth in the minds of those who are really interested. Perhaps the field of mechanics should come later in the physics rather than at the beginning because the concepts in mechanics are more difficult. However, an experiment to make the change and/or other experiments more or less similar might be rather costly and yield negative results. No one has ever proved that the logical order of physics for the most part is not the most psychological order for the learning of many pupils.

Another mode of thought today is that the science teacher does not have to know a great deal of subject matter but that the science teacher should help the pupil with "how to find" science. Developing in the physics pupil an attitude of looking up information is surely a worthy objective of a physics teacher. But the teacher's assistance to the pupil in the development of the "know-how-to-find" attitude is no excuse for the teacher's lack of knowledge of physics.

You should know all the physics that you can learn before you become a teacher of physics. Then as you begin to teach you should keep on the alert for the recent developments and advancements in the field. Reading about these you can and will want to do, and through reading, you will like your teaching all the more. About every second or third summer you should attend summer school and during the summers that you are not attending school you should make visits to laboratories of industry and government so that you can see what is being done in a more real and tangible way.

If you try to keep up with what is new in physics and keep experiencing the difficulty of learning new physics, you will appreciate what the pupils are tackling each day. Too, the teacher must also continually feel the thrill and inspiration of seeing and understanding for the first time some recent viewpoint or material in physics in order to enjoy new knowledge. Put yourself in the pupil's place as a learner and try to see his problems and his enjoyment through his eyes. But, let me repeat the idea of the importance of a knowledge of subject matter. Be ahead of the pupil in "the tried and found true" subject matter of physics. Knowing the method for learning the different parts of physics and their comparative difficulty, you will be better able to guide the pupil through the maze of learning and to know more nearly how much to expect of him. You cannot help the pupil to develop insights into the fundamentals of physics unless you yourself already have these insights.

What type of college education should a prospective physics teacher have? The prospective physics teacher must prepare herself to teach humankind; therefore the physics teacher needs a liberal arts background. Also the prospective physics teacher must prepare herself to teach physics and to understand its relationship to other sciences; therefore the physics teacher needs an adequate background in the fundamentals of science and mathematics with emphasis on physics. A prospective physics teacher should obtain approximately thirty-six to forty semester-hours during each undergraduate year. This should not be too much because some of the time is in the laboratory, which should mean a mental relaxa-

tion. The courses and semester-hours, I think, that give the proper balance between the liberal arts and the sciences with emphasis on physics and that provide the best training for a prospective physics teacher are shown in the outline of Table I. A suggested schedule of courses and semester-hours for the five years that it takes to make a good physics teacher after high school training is shown in Table II.

TABLE I

OUTLINE OF COURSES AND SEMESTER-HOURS TO BE TAKEN BY A PROSPECTIVE PHYSICS TEACHER

General Field	Name or Description of Courses	Number of Semester-hours	Total Semester-hours per Field
English	Rhetoric and Composition	6	18
	Literature, English and American	6	
	Classics, Latin & Greek	6	
Social Studies	U.S. History and Government	6	18
	European History	6	
	Psychology and Sociology	6	
Language	Any combination of French, German, or Russian		24
General Education Science	General Education Science or Astronomy and Geology (if biology, chemistry and physics have been taken in high school)	6	6
Chemistry	Inorganic	8	16
	Organic	8	
Physics	Elementary	8	32
	Mechanics and Electricity	8	
	Heat, Sound, and Light	8	
	Modern, including Atomic and Nucleonic and Electronics	8	
Mathematics	Trig. and Analytical Geometry	6	24
	College Algebra and Calculus	6	
	Differential Equations and Vector Analysis	6	
	Fundamental Concepts of Modern Mathematics	6	
Education	History of Education, Hygiene	6	24
	Secondary Education, Class Management, Tests and Measurements	6	
	Educational Psychology with emphasis upon the Psychology of the Adolescent	6	
	Teaching of Science, including the history and philosophy of as well as the methods of teaching and trips to places of scientific interest	3	
	Practice Teaching (This should include not only teaching by the student but also as many visitations to as many different teachers of physics as is possible.)	3	
Electives			12

TABLE II

SUGGESTED SCHEDULE OF COURSES AND SEMESTER-HOURS FOR THE FIVE YEARS OF COLLEGE STUDY OF THE PROSPECTIVE PHYSICS TEACHER

Freshman		Sophomore		Junior		Senior		Graduate	
English	6	English	6	English	6				
Social Studies	6	Social Studies	6	Psychology	3				
				Sociology	3				
General Education Science	5	Chemistry	8	Chemistry	8				
or									
Astronomy	(3)	Physics	8	Physics	8	Physics	8	Physics	8
and									
Geology	(3)								
Mathematics	6	Mathematics	6			Mathematics	6	Mathematics	6
Language	6	Language	6	Language	6	Language	6		
				Education	6	Education	12	Education	6
Elective	6					Elective	6		
Total	36	Total	40	Total	40	Total	38	Total	20

A COMPARISON OF THE EFFECTIVENESS OF A LECTURE METHOD AND A SMALL-GROUP DISCUSSION METHOD OF TEACHING HIGH SCHOOL BIOLOGY *

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FOR many years the most prevalent teaching method has been the lecture-recitation method. A body of tradition has been built about this well entrenched method. These traditions have been a barrier to the adoption of newer methods. Changing conditions in a modern world, knowledge of the psychological factors controlling learning, and increased understanding of the needs of a complex democratic society made examination of teaching methods necessary.[1] Concern for finding objective evidence to use in altering methods of teaching in science classes led to this investigation.

1. THE PROBLEM

The basic problem was the investigation of the relative merits of two methods of teaching high school biology. The methods involved lecture and small-group work with groups being set up in one case by random procedures and in the other case by sociometric procedures.

This study was limited to three biology classes at Amphitheater High School in Tucson, Arizona. Two teaching methods were used. One class was taught by individual study, lecture, and class discussion. The other two classes used small-group work in place of lecture to secure information. The groups in Class 2 were formed by random procedures while those in Class 3 were formed by using data from sociometric tests. The variable under study was lecture versus small-group work. The problem was further defined by the following questions.

Question 1

How will the achievement of subject matter by students in biology classes compare due to the various teaching methods?

Question 2

How will the achievement of subject matter by students in the upper, middle, and lower third of the biology classes compare due to the various teaching methods?

* Summary of an Unpublished Doctor's Field Study, Colorado State College of Education, Greeley, Colorado.

[1] Bossing, Nelson L., *Teaching in Secondary Schools*, p. 136 and p. 149.

Question 3
How will the achievement of subject matter by poor readers in biology classes compare due to the various methods?

Question 4
How will the retention of subject matter by students in biology classes compare due to the various teaching methods?

Question 5
How will the retention of subject matter by students in the upper, middle, and lower third of the biology classes compare due to the various teaching methods?

Question 6
How will the fifteen factors of personality of students in biology classes, as determined by the California Test of Personality, be affected by the various teaching methods?

Question 7
How will the over- and under-achiever in biology classes be affected by the various teaching methods?

Question 8
How will the accumulative effect of practice in a given method by students in biology classes affect achievement due to the various teaching methods?

The null hypothesis of no difference among the classes except that accounted for by chance variation was tested for the characteristic involved in each of the eight previous questions.

2. THE POPULATION

The classes used in the study were three of eleven biology classes set up by the deans in the normal procedure of registration at Amphitheater High School during the school year 1954–55. Biology was required. This was a four year high school of about 1,000 students located on the northern fringe of Tucson, Arizona. The area and the school population were socially heterogenous. Analysis of variance was used to determine whether the classes were significantly different on initial characteristics such as sex, age, grade level, I.Q., grade point average, reading ability, knowledge of biology, and personality factors. There were so few significant differences that it seemed a defensible position to conclude that the classes differed only by chance and that they could be considered to be random samples from the same population.

All classes were treated alike in that they had the same textbook, study sheets, visual aids, and laboratory equipment as well as being taught by the same instructor in the same room with the same units of work presented in the same order. All classes had the same amount of time for individual study preceding lecture or group work as well as the same opportunity for class discussion of those things they didn't understand on the study sheets. At the conclusion of any section of work identical tests, or forms of the same test, were given to all classes. All classes were taught by the lecture method during the first six weeks. All classes received the same orientation in role playing near the end of the first six weeks. As was decided before the classes were organized the first class of the day (Class 1) continued to be taught by the lecture method throughout the year while the second class of the day (Class 2) and the third class of the day (Class 3) were taught by the small-group discussion method throughout the rest of the year. The difference in the methods used with the classes resided in the fact that the time used for lecture in Class 1 was used for small-group discussion based on the study questions and textbook in Classes 2 and 3. At all times great care was taken to equalize any influence the instructor might have outside the lecture-group work variable so that no biasing factor would be introduced.

In Class 1 study time was followed by lecture. Following the lecture a reasonable amount of time was allowed for questions from the class so that ideas that were not clear could be discussed and clarified. In Classes 2 and 3 individual study time was followed by small-group discussion. The time allowed for small-group discussion was equal to that used for lecture in Class 1. In the small groups the individuals were to work together to find the answers to the questions of the study sheets. The textbook was the only authority available to them. Following the group work the same amount of time was allowed for questions

from the class as was allowed in the class taught by the lecture method. At this time questions not adequately answered by the book were, if asked for, considered further.

3. TECHNIQUES AND PROCEDURES

The analysis of covariance technique was finally selected as the most appropriate method for analysis of the data concerning Questions 1 through 6 of the study. Hence initial and final scores were needed on a number of characteristics. Knowledge of biology was determined by using the Cooperative Biology Test as a pre- and post-test. Knowledge of the Units on Conservation, Nutrition, and Behavior was secured by using teacher-made tests as a pre- and post-test. Knowledge of personality factors came from the California Test of Personality used as a pre- and post-test. An IQ was secured for each student from the Otis Mental Ability Test and a reading score was secured from the Reading Comprehension section of the Cooperative English Test.

To find the answer to Question 7 correlations for I.Q. and the Cooperative Biology pretest and correlations for the I.Q. and the Cooperative Biology post-test were secured for all three classes. After converting the r's to Fisher's Z's a t test of difference between Z's was made.

In processing the data for Question 8 the analysis of variance technique was used. The data was placed in a double entry table with classes as columns and teaching units as rows. The scores used were the differences between the pretest and post-test scores of the Conservation, Nutrition, and Behavior tests.

4. INTERPRETATIONS, CONCLUSIONS AND RECOMMENDATIONS

A. Interpretations

The first question was concerned with the achievement of subject matter by students due to the various teaching methods. The Cooperative Biology Test gave an over-all test of achievement for the whole course. The F test was less than 1, indicating no significant difference in achievement among the classes.

The units selected for special testing during the year were Conservation, Nutrition, and Behavior. The F tests on Conservation and Nutrition also were too small to indicate significant differences in achievement. But the F test on Behavior indicated a difference in achievement not accounted for by chance. Classes 2 and 3 were superior to Class 1, while there was no significant difference between Class 2 and Class 3. These differences will be discussed during consideration of Question 8.

The second question was concerned with the achievement of subject matter by students in the upper, middle, and lower third of the biology classes due to the various teaching methods. The F tests for over-all achievement and for unit tests showed no significant differences among classes at any of the levels except the lower level for the Unit on Behavior. The lower third of Class 3 was superior to the lower third of Class 1, while there was no significant difference between Classes 1 and 2, and Classes 2 and 3 at the lower level. This difference will be discussed in consideration of Question 8.

The third question was concerned with achievement by poor readers due to the various teaching methods. The lowest ten of each class in reading ability were compared for over-all achievement and achievement on units. The F tests indicated no significant differences in achievement.

The fourth question was concerned with the retention of subject matter by students due to the various teaching methods. There could be no test of the over-all retention of subject matter because of the disintegration of the experimental classes at the end of the year. The best that could be done was to retest the classes on the units after some time was allowed to elapse. The F tests showed a significant difference in retention only in the Behavior Unit. Both Class 2 and Class 3 were superior to Class 1, while

there was no significant difference between Class 2 and Class 3. These differences will be discussed during consideration of Question 8.

The fifth question was concerned with retention of subject matter by students in the upper, middle, and lower third of the biology classes due to the various teaching methods. The F tests for the units showed no significant differences among classes at any of the levels of the units except the upper level of the unit on Behavior. The upper third of Class 2 was superior to Class 1, while there was no significant difference between Classes 1 and 3, and Classes 2 and 3 at the upper level. These differences will be discussed during consideration of Question 8.

The sixth question was concerned with the effect of the various teaching methods on fifteen factors of personality of the students in biology classes. These factors of personality were measured by the California Test of Personality used at the beginning and end of the year. The F tests showed no significant difference among the classes in Total Adjustment, Personal Adjustment, Social Adjustment, or any of the twelve subfactors. Apparently, the teaching methods had no effect or were equally effective on the classes.

The seventh question was concerned with the effect of the teaching methods on the over- and under-achievers. By comparing the increase in correlations between I.Q. and biology pretest, and I.Q. and biology post-test, some conclusions perhaps could be drawn about the effects of the teaching methods on over- and under-achievers. The initial correlations were so different from each other than they could not be considered as random samples from the same population. If Class 2 was disregarded some knowledge could be gained from Classes 1 and 3, which were initially more nearly alike. Classes 1 and 3 initially had r's of .37 and .49 respectively. Finally they ended up with r's of .51 and .69 respectively. Class 3 started at a higher level and grew more. Converting the final r's to Z's and making a t test of difference ruled out the possibility of difference in Z's and consequently r's. If this difference was not significant no other final differences could be significant. Therefore, there was no significant difference in the effect of the teaching methods on the over- and under-achiever.

The eighth question was concerned with the effects of the teaching methods on the achievement of the classes with the passage of time. With the passage of time and the subsequent practice in group work, which was something new to the subjects involved in the experiment, improvement might become evident. For this reason, the tests were given on the three units taught at different times throughout the year. By using an analysis of variance in a double entry table, differences among units could be removed. The F test showed a significant difference among class means for combined units. Class 3 was significantly better than Class 1. No other significant differences were evident. The F tests also showed significant differences among the means of the Behavior Unit. Here, as in the previous analysis, Classes 2 and 3 were superior to Class 1, but Class 2 and Class 3 showed no difference.

Some factor was operating to create a significant difference in over-all achievement and retention of the information of the Behavior Unit. Classes 2 and 3 were superior to Class 1 in both achievement and retention. Also, the lower third of Class 3 was superior to the lower third of Class 1 and the upper third of Class 2 was superior to the upper third of Class 1. Various factors may be responsible for these differences. Perhaps the passage of time allowed the benefits of group work to finally come to expression. There may also have been something in the nature of the unit that interacted with people working in groups that accounted for the difference. Still a third possibility was that as time passed the students in Class 2 and Class 3

learned to borrow more answers from the morning class which was Class 1. All did have the same tests with Class 1 having them first, Class 2 second, and Class 3 third. About all that can be said is that some factor was operating to cause Class 2 and Class 3 to be superior to Class 1 in the Behavior Unit. To determine more would demand the designing and carrying out of another experiment.

B. Conclusions

Certain conclusions have been drawn on the basis of the results of the study. They are as follows:

1. High school biology students will achieve as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
2. Regardless of the initial knowledge of biology, when compared with others of the same initial level of achievement, high school biology students will learn as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
3. High school biology students of poor reading ability will achieve as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
4. High school biology students will retain as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
5. Regardless of the initial knowledge of biology, when compared with others of the same initial level of achievement, high school biology students will retain as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
6. The personality adjustment of high school biology students, as measured by the California Test of Personality, will change at the same rate whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.
7. The methods used to determine how the over- and under-achiever in high school biology would be affected by the lecture method or the group discussion method using either random groups or sociometric groups were probably invalid and hence no safe conclusions could be drawn.
8. As time passed some factor began to operate among the high school biology students so that those taught by the group discussion method, whether random or sociometric, achieved more in the unit than under study than those taught by the lecture method.
9. On the basis of factors measured in this study, one must conclude that the methods of instruction investigated were equally effective.

C. Recommendations

1. Since there doesn't seem to be any "best" method of teaching, as evidenced by this and other studies,[2] teachers should for the present use that method which is most convenient and satisfying.
2. Since the teaching methods used in this study were equally effective when learning experiences were held constant, a series of studies should be designed and executed to determine the effectiveness of various methods and experiences when combined. The effectiveness of continued treatment over several years at various age levels should be determined on such factors as achievement, personality adjustment, social climate, and attitude changes.
3. A study or studies should be designed to determine what factor was operating to cause a significant difference on the Behavior Unit as taught in this study.

[2] Stiles, Lindley J.; Cary, Stephen M.; and Monroe, Walter S., "Methods of Teaching," *Encyclopedia of Educational Research Revised Ed.*, p. 748.

THE PREPARATION OF A REGIONAL INDUSTRIAL INFORMATION MANUAL FOR SCIENCE TEACHERS *

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This project grew out of the belief that science teachers at all levels of instruction can enrich their teaching of both physical and biological sciences by:

1. Correlating textbook principles and laws of science with actual applications in local and regional industry.
2. Helping students gain an appreciation of the use of the scientific method of problem solving by showing how community industries apply this method in their daily use of science.
3. Making use of the community and regional resources offered by the industries.
4. Learning enough about the regional industries to be able to make wise choices when using the industrial resources.

THE PROBLEM

The purpose of this study was to develop a manual of information about the industries of northwestern Alabama for use by the teachers of science in this geographical area.

DEFINITIONS

Manual. As it applies in this study, a source of information concerning the raw materials and their sources, energy sources, descriptions of manufacturing and other industrial processes, pertinent bibliographies, sources of industry-sponsored informational materials, and possibilities for field trips to and field services of the industries of northwestern Alabama.

Industries. Those commercial or governmental activities involving the production of raw materials and the processing of raw materials or prefabricated or partially processed parts or materials but not including agricultural products not industrially processed in the area concerned.

Northwestern Alabama. As the term is used in this study, this area coincides with the Florence State College service area consisting of these counties: Colbert, Cullman, Fayette, Franklin, Jackson, Lamar, Lauderdale, Lawrence, Limestone, Madison, Marion, Morgan, Walker, and Winston.

METHOD OF OBTAINING INFORMATION ABOUT THE INDUSTRIES

It was felt that in order to produce a worthwhile manual of information for science teachers, it would be necessary to know at first hand the nature of the subject matter to be included. Because of this conviction, the writer determined to visit personally every representative industry in the area and make a comprehensive study of each one.

The Alabama State Chamber of Commerce publication, Industrial Alabama [1] served as a source for names and addresses of the industries in the fourteen counties included in the study. Custom service firms such as sheet metal shops, printing shops, and roofing and heating companies were not included. The number of industries manufacturing or processing one or more standard products finally selected was about 400. Among these 400 industries, there is considerable duplication of raw materials, products, and processes. There are, for

* A report of the methods used in the development of the author's doctoral study for the degree of Doctor of Education in the School of Education, New York University. Document title: *The Preparation of a Science Teachers Manual of Information About the Industries of Northwestern Alabama.*

[1] Alabama State Chamber of Commerce, *Industrial Alabama, A Directory of Manufacturers,* Alabama State Chamber of Commerce, Montgomery, 1955.

instance, twenty-one manufacturers of concrete building blocks, twenty-six carbonated beverages bottling companies, and fifty-four lumber mills in the area. By elimination of duplications of this sort, there remained 125 different representative industries to be visited and studied.

Several pilot studies were conducted to determine the most satisfactory method for visiting and studying the industries. It was found that the following sequence of actions saved time, travel, and expense:

1. The investigator, armed with a letter of introduction from the president of Florence State College, selected the industries to be visited during a given day.

2. Upon arrival at the business offices of an industry, the letter was presented to the receptionist with the request that she read it and then, if convenient, arrange an interview for the investigator with the appropriate company personnel. No preliminary contact of any kind was ever made (making appointments by mail or telephone was too time-consuming and frustrating) and in most cases the requested interview was arranged immediately.

3. During the office interview with some official of the firm, information concerning the nature of the raw materials, energy, types of products, production figures, available teaching materials, and possibilities for field trips or field services was obtained. The investigator was always careful to let the company personnel know that he did not want to know or see anything the company did not want to make public.

4. The interview was usually followed by a conducted tour of the manufacturing section of the industry. It was during this trip through the plant that most of the information concerning manufacturing processes was obtained.

The information obtained during the interview and the plant tour was recorded on three pages of a mimeographed industry information form conveniently attached to a clip board along with the letter of introduction. The development of the industry information form and the selection of a type of organization for the collected information was accomplished with the aid of an advisory group of area educators. This group was selected to be representative geographically as well as academically. The twelve members were science teachers from the elementary schools, junior and senior high schools, and the three colleges in northwestern Alabama. Since a primary objective was to produce an educational aid of real value to teachers, it was assumed that this value would be enhanced if some of the teachers could take part in the planning and development phases of the project.

ORGANIZATION AND SYNTHESIS OF INFORMATION

The final accumulation of 125 completed, three-page industry information forms, numerous booklets, pamphlets, leaflets, and magazines, and an impressive collection of samples of products and raw materials, had to be organized on some logical basis before the writing of the manual could begin. To begin with, a separate file card was prepared for each of the 400 industries. These cards listed the name and location of the industry along with the principal products, raw materials, and manufacturing processes. The cards were then used in working out tentative organization plans. Organizations bases on geographical location, raw materials, and manufacturing processes were considered and discarded in favor of a plan based on products produced by the industries. The products organization seemed to provide the better basis for a manual that might be of maximum benefit to the teachers for whom it was designed.

The classes of industries with the number of representatives in each were: agricultural products processing (134), chemical (15), concrete and ceramic products (32), forest products (92), leather, plastics, and rubber products (8), metals and metals products (27), mines and quarries (30), textiles and garments (38), miscellaneous products

(12). Most of these classes were divided into convenient sub-classes. Mines and quarries, for example, were discussed in the manual as six separate categories: clay, asphalt, coal, iron ore, sand and gravel, stone.

WRITING THE MANUAL

With the exception of the first one, the chapters into which the manual was divided naturally followed the main classifications of the industries with respect to the products manufactured. Chapter I, Introduction, dealt with a number of general topics that would have been somewhat fragmented if they had been treated in the other chapters. These topics were:

The purposes for which the manual was designed.
Some general suggestions about how teachers could use the manual.
A description of the geographical area covered in the manual.
The general nature of the industries.
How the manual was organized and some specific suggestions for using it.
Industry-sponsored teaching aids.
The possibilities for field trips.

In discussing an industry or a group of similar industries, no effort was made to conform to a set pattern in hopes that variety of approach would minimize monotony of repetition. In further efforts to make the manual easy to read and as interesting as possible, considerable reliance was placed on the principles of writing expressed by Flesch.[2]

The manual was not written with any particular group of teachers in mind. It was hoped that the approach and writing would be general enough to serve the needs of the elementary school teacher, but, at the same time provide information of interest to the college instructor.

A 1,075 item index was included so that reference to any industry, locality, raw material, product, or manufacturing process could be made quickly and easily. Footnotes were limited to definitions of terms or explanations of items in the text with which some of the prospective readers might not be familiar. Numbers in parentheses corresponded to numbered notes at the ends of chapters referring the reader to additional information on the subject—either in this manual or in standard reference works.

CONCLUSION

It is hoped that when this manual is published and distributed to the science teachers of northwestern Alabama, that it will stimulate them to make more and better use of their regional resources of an industrial nature.

If similar projects in other small regions could be completed by individuals, organizations, or institutions, it might constitute a valuable step forward for science education and industry in our country.

[2] Rudolf Flesch, *The Art of Readable Writing*, New York: Harper and Brothers, 1949.

MRS. OTIS W. CALDWELL

THE many friends and acquaintances of Mrs. Otis W. Caldwell and the late Dr. Otis W. Caldwell, will be sorry to learn of Mrs. Caldwell's death at her home at New Milford, Connecticut, May 8, 1959. She was buried beside her husband in the cemetery at New Milford. Among the surviving relatives are her daughter Mrs. George A. Harrop, Jr., Cherry Hill Road, Princeton, New Jersey and Dr. Nathan A. Neal, a nephew and N.A.R.S.T. member.

CLARENCE M. PRUITT

WHO IS INTERESTED?

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The interest during the past decade in American education, with particular reference to education in the sciences, has provoked a great deal of discussion and an equal amount of plans and proposals for developing scientists. The arrival of Sputnik upon the scene has served to crystallize much of this discussion into definite plans of action that presumably will be activated in the near future. There appears no question as to what the desirable end-product should be: creative scientists, particularly in the physical sciences. This product must be produced in the shortest possible time and in the largest possible numbers. The analogy to the "war effort" of 1942 needs no explanation and the majority of recent proposals shows a striking similarity to those used during that era; construct or expand the plants (in this case schools and colleges) that are already available and use tax money to raise the salaries and financial remuneration to all involved in the project. By this analogy the young people of America bear a striking resemblance to the raw steel that was turned into tanks, planes and guns. It is with this last analogy that exception is taken and wherein the entire system is likely to break down, producing either intellectual robots as fixed in design as the M-1 rifle or, more probably, no end-product at all.

Consider a hypothetical hard-headed business man who discovers a desirable commercial end-product. Would his first step in its production be to build or extend his manufacturing plant and the second to raise the salaries of all his workers? Most likely not. Surely he would first attempt to discover how the product was made and then modify his operation and wage scale, if necessary.

If this analogy seems absurd consider if anybody has seriously asked scientists why they become scientists. If the answer to this seems obvious notice some of the dichotomies produced by present proposals for producing an abundance of such people. They would first suggest that a number of individuals, with above average intelligence, chose a field of endeavor in which the financial remuneration was exceptionally low. If money were the motivation does this sound like an intelligent choice? They might further suggest that fame or prestige were the incentive. Few people do as much writing for a limited audience, in academic journals, as scientists or produce as much commercial material for which personal recognition is lacking.

It would appear there is only one common denominator for all PhD's and their many co-workers who often lack the degree. That denominator is interest; an intense interest in a particular field. It is a curious phenomena that you find this intense interest in two widely different segments of our population; the young child and the mature scholar. The fact, existing today, that the latter is in short supply, particularly in the natural sciences and more specifically in mathematics and physics, might cause our hypothetical hard-headed business man to ask why a normal number of interests were not channeled into those fields.

The answer to this question may be apparent if the present scientists were polled as to why they went into their present field. In the majority of cases, it would not be remuneration nor fame but rather an individual or two with whom they became associated whose interest in a particular field of study was infectious for them. It may have been a parent, a teacher or an employer, but it was somebody, not something.

Many modern concepts would have you believe that we can screen our molten mass of youth, pluck the intellectual plums and put them on a conveyor belt through the pre-fabrication plant designed to produce scientists with the promise that they will be economically well-off if they hang on to the belt. This may work in Russia, where to get off the belt would be to plunge to oblivion, but in America, the side-show lends too many temptations and rewards to expect an intelligent youth to remain fast.

At the present time there are many financial aids to higher education, such as teaching and research assistantships, available. Many are not filled because of a lack of graduate students. Can more money in the form of federal fellowships change this situation? It would not seem logical. The incentive for graduate study must come from within the individual and this incentive must be nourished over a period of years. Few students decide suddenly "now that somebody will pay me $2,000 a year to study physics I think I'll become a physicist and turn down that $5,000 job I was considering." This is not to argue for a reduction in financial assistance to graduate students but rather to indicate that financial assistance is secondary to interest and incentive.

There has been much discussion of the fact that a large number of American high schools offer no course in either physics or chemistry. Has anyone inquired as to what percentage of students, who took physics and chemistry in high school, have become physicists or chemists? It may demonstrate that as many students enrolled in such courses have been discouraged from studying these fields as have been encouraged. The increased availability of such courses, desirable as it may be, is no guarantee of a comparable increase in specialists in that field. It is a curious situation that in those sciences, concerning which we have the most precise knowledge, we, today, have the greatest deficiencies. There appears a very plausible reason for this.

An elementary course in mathematics or the physical sciences leaves little room for conjecture or speculation. The student is told to learn "these well established facts" and then after a few years of such courses he may begin to look into the unknown. The biological sciences run a close second to this situation but the mystery of life and the theory of evolution permeate all biology and allow even the freshman to theorize. The social sciences begin, in basic courses, with discussion and controversy concerning phenomena the student has already experienced. These are the major fields into which the potential scientist brings his naturally inquiring mind. Which field is going to appear more appealing to such an individual? Ask a student in a begining physical science course what is yet unknown in that field and ask the same question of a student in psychology or sociology. This is a simple test almost any interested American can make. If the physical science student can tell you, make every effort to retain his teacher. That teacher is creating interest; for it is primarily toward the unknown that our interest is attracted. Many Americans over thirty can recall a required history course composed primarily of names and dates to be memorized. Most of these individuals have little use for history today. It was dead when they took it and it stayed that way.

This is not an argument for removing factual material from courses, (although in courses where its been done the enrollment has often soared). It is a suggestion that fact and speculation can, and should be, integrated in elementary courses. A teacher that can accomplish this will incite interest in that subject and that teacher is the most needed commodity in America today. What is even more hopeful is that this type of teacher can potentially be found in schools all over this country once he is liberated from the conformity which is now frequently

demanded of him. A conformity that often stifles individual imagination and the same spark of interest that induced that teacher to choose his particular field in the first place.

The well known adage concerning horses and water seems very applicable to the American students of the future. You can build beautiful buildings and extravagant laboratories. You can offer financial compensation as bait, and in America you can do this overnight, but you can't change human motivation in the same twinkling. If American people want technological supremacy in the world and expect their youth to achieve it, they must first realize it can't be bought with money alone. It must be achieved with the expenditure of "heart"; a growing understanding and interest in the disciplines of science that becomes infectious for their youth. The parent, the teacher, the employer that points out horizons they may never reach, but which interest and inspire youth, are the hope of America's scientific future. Develop this attitude in America's adults and American youth will do the job required of them.

RESULTS OF A JUNIOR HIGH SCIENCE INTEREST SURVEY

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It seems legitimate for the sake of better, more dynamic, and more fruitful teaching of junior high science to investigate and tabulate pupils' preference so that most effort may be expended by the teacher on those divisions of the subject which will appeal to them and which they can readily make integral parts of their living experiences. For if interest is a natural tendency to action, and if by building instruction on interests which pupils possess, the result is higher achievement with greater ease, then we must discover the interests and use them in the teaching program. The pupils' needs in daily life greatly intensify interests. Since the school program or curriculum is developed for the pupil, the pupil should have a major part in the planning of the curriculum.

Research clearly shows that the interests and preferences of pupils are important in the planning of classroom procedures and in the choice of topics to be studied. The purpose of this survey was to discover the interests and the preferences of junior high school pupils concerning science.

A questionnaire-survey was administered to the seventh, eighth, and ninth grades of two junior high schools in Watertown, Massachusetts. One junior high school in the study was situated mainly in a residential area, the other junior high draws from an industrialized area; a good cross section of pupils representing both a manufacturing community and a residential community was obtained. Nine hundred twenty-two pupils completed the questionnaire. The instrument consisted of three pages. Page one permitted the pupils to write any number of selections of science topics in which he was interested, or which he would like to study. Page two contained sixteen general science topics under general headings which were listed in ten general science text books. The pupils were requested to check all topics in which they were interested or that they would like to study. Page three contained questions which referred to the topics mentioned. These questions were in a random order but there were four questions which were related to each topic. The reason for page three

was to attempt to discover if there was consistency between these selections and the selections on page two. Again the pupil was asked to check any item of interest. The data were tabulated by totalling the preferences according to:

1. Total number of pupils checking each topic, by grades.
2. Rank of science topics of boys and of girls, by grades.

The statistical results can be best shown by evidence illustrated in Table I. To facilitate reading, the results expressed in the table show only the first six selections from each page. There appears to be a fair consistency in items of interest. The break-down of boy-girl interests showed a greater consistency of interests by sex. The conclusive evidence evaluated from this survey indicates that the scientific interests of the child are an important factor in class room planning for the needs of the children.

There appears to be a fair amount of consistency in the selection of topics having high interest value. It is evident that information concerning the solar system is desired by most of the pupils. Next comes information regarding the origin of the earth (probably stimulated by the recent articles in *Life*). The majority of the boys expressed a desire to learn more about electronics. The girls selected animal life. Magnetism and electricity were also high-level choices of the boys. Surprisingly enough, weather seemed an important issue with the girls. Many of the boys selected the topic "air" probably because of their interests in airplanes and the air war being fought at the time in Korea. Many girls were also interested in plant life, contrasted to the boys who expressed little desire to study that topic. Also might be mentioned the interest in health expressed by the girls while the boys gave little attention to the subject.

TABLE I

PERCENTAGES OF PUPILS RESPONDING TO EACH OF THREE SETS OF ITEMS

Grade 7			Grade 8			Grade 9		
Original Write In	Selected Items	Selected Questions	See Col. 1	See Col. 2	See Col. 3	See Col. 1	See Col. 2	See Col. 3
33	39	38	32	45	..	..	..	..
44	43	37	36	52	..	47	62	22
..	..	..	..	..	..	..	55	..
41	42	..	37	52	65	40	64	..
..	..	34	..	..	..	..	..	32
..	28	..	..	..	..	..	..	..
..	..	..	..	44	..	..	55	23
..	..	29	..	..	53	24	..	..
37	..	31	30	..	54	29	..	..
..	33	..	..	..	..	..	..	..
..	..	30	..	..	..	28	..	..
43	..	..	31	48	65	..	57	29
46	38	..	36	53	61	37	59	25
..	..	..	..	52	52	..	..	..
..	..	..	..	..	..	..	..	25
..	..	..	..	..	..	..	..	..

1. Air
2. Animal life
3. Conservation
4. Electronics
5. Heat
6. Health
7. Light
8. Machines
9. Magnetism & Electricity
10. Matter and energy
11. Plant life
12. Origin of the Earth
13. Solar system
14. Sound
15. Water
16. Weather

Probably the only reliable check was the

first page where the pupil had a chance to write in his own selection. The other two pages circumscribed the choice of the participants. A criticism offered, subsequent to the findings, was that the pupils had no occasion to voice their dislikes, and such a study would help in evaluating.

However, the survey reveals the interests of these pupils concerning topics of science. The results may be an indication of the needs of junior high school pupils.

It might be added that it was difficult to place some of the original selections by topics obtained from page one. It was felt however, that placing them in the category of the major topics listed in the general science text books would allow comparison with the other two pages.

A COLLEGIATE DEPARTMENT OF SCIENCE EDUCATION: ITS FUNCTION AND IMPORTANCE

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It is not a matter of chance that certain colleges and universities lead the nation in the quality and quantity of science teachers graduated. Each of these institutions has departments or divisions in which science education is a coordinated but separate entity. In these schools the science education function is the point of integration between academic science and professional education. It is responsible to both, dependent on both, and demanding of some special consideration from each. Where science education is not a functional entity, vital communication is likely to be lacking between departments of education and the natural sciences. All too often in these places bickering and sniping "across campus" have effectively reduced the number and competence of the science teachers produced. A department of science education is the ideal arrangement for carrying on certain functions that cannot or may not be performed adequately or efficiently either by a teacher education department alone or by departments of the academic sciences.

Science education is a professional discipline based upon academic areas of learning in precisely the same sense as engineering, medicine, or public administration. In any profession, preparation includes work in the academic areas designed to provide the foundational knowledge for the practitioner. In addition, and no less important, the preparation of a professional worker must include training in the specific techniques of his calling so that he will be able to employ effectively the fundamental knowledge he possesses.

In most colleges and universities, the academic science preparation of the science teacher is a function of the science departments. In very many cases, however, the resultant product is rather narrowly prepared in one discipline or a closely related group of disciplines. For example, the potential science teacher may be developed as a competent zoologist. As a specialist of this nature he may be fully fit to do research or carry on some other form of technical work in the field of zoology. He is, nevertheless, incompletely prepared to be a teacher of science in virtually all of the pre-collegiate schools in the nation. For the latter he should be a generalist, trained as widely *and as deeply* in *all* the sciences as the prescribed period of preparation will permit. Only through a coordinated program of training in the various disciplines, as taught by the academic science departments, can the science teacher candidate become fully capable of doing the job that will be expected of him. The coordination and the student advising which implements the program are properly the function of the professional department which is most

closely associated with the science departments and which is most familiar with available courses and work requirements. This is a science education function.

In many colleges and universities the entire professional preparation of all teachers, science teachers included, is the function of the department of education. In some cases there are education faculty members with academic science backgrounds who see to the professional training of the science teachers-to-be. In larger departments of education there may be specific courses devoted to the techniques of teaching science. Further discussion of special "methods" courses is to be found below. The role of the department of education in the preparation of science teachers, as for teachers in other subject matter areas, is instruction in the general professional content and skill areas. Within these areas should be included the legal bases of the public schools, the history and ethics of the profession of teaching, the applications of foundational learning such as psychology, the proper use of instructional methods and devices common to all subjects taught in the schools, etc. A further function of the department of education is the coordination and prescription of courses which are foundational to the study of professional education. Psychology and sociology, at least, must be numbered among these foundations.

In the culmination of thorough academic science training and basic professional preparation, as well as the general education required by the informed person lies the unique function and importance of the department of science education. This is the organization devoted to welding all the individual has learned into an integrated, applicable whole which makes the difference between the science teacher and research scientist, or the difference between the science teacher and the language teacher. Just as the engineer needs to be taught specific techniques of applying his basic or fundamental knowledge to solving problems of construction or operation, so must the science teacher be instructed in the techniques for solving the varied and complex problems inherent in the teaching of science to children with incredibly divergent backgrounds, interests, and abilities. Science teaching is bound to the subject matter of science. "There is no method without content." It is impossible to teach unless there is something to impart, be it information, skills, or attitudes.

"There is no substitute for experience." It would be foolish to attempt to refute this truism! Experience is exactly what methods or techniques courses are designed to provide. It is, to be sure, very basic experience which requires further expansion. Some expansion is provided initially through supervised student teaching which precedes entry into full-time teaching. It is through such a system that children are afforded a large measure of protection from incompetents in the roles of teacher.

The specific techniques in the profession of teaching are quite different from the techniques peculiar to the practice of law or architecture. There is a region of common ground in the techniques of teaching at all levels and in all subject matter areas. There is, just as surely, a pattern of variation and difference among teaching techniques which are dependent on the grade level and the subject matter to be taught. In the same sense that dentistry and ophthamology, though in some ways related, have widely divergent methods, so is there divergence in the methods of teaching physics and mathematics. Also divergent, obviously, would be the techniques of teaching general science in the junior high school and nuclear chemistry in the college. Nevertheless, in all of these cases there are specific methods, techniques, procedures, and means of attaining the desired results. The specific techniques and procedures which are designed to lead toward excellence in science teaching are a part of the content of a science "methods" course.

Methods courses in science, in considera-

tion of the differences inherent in preparation for teaching at various grade levels, are divided into several separate courses as far as is convenient and yet efficient. Thus, basically, there should be a separation between science methods courses for the elementary school teacher and for the secondary school teacher.

The elementary school teacher is most commonly assigned to a "self-contained" classroom in which virtually all areas of knowledge are taught, albeit at a rather simple level, by the one teacher. This presents a tremendous task to those responsible for the proper education of the elementary school teacher. To prepare a person to teach well a large number of facts, skills, and attitudes must necessarily involve a great many compromises if anything is to be accomplished in such a ridiculously short period as four or five years. One compromise in science education is simultaneous work in the content of science appropriate to the elementary school and in the techniques of presenting this content to the pupils. In part, this is accomplished by exemplary teaching following the assumption that teachers, in turn, teach as they were taught. In addition, the broad areas from which content is selected commonly cut across the traditional boundaries of formal disciplines. For these reasons science education must request that generalized courses be offered by the academic science departments and taught by instructors familiar with both the subject matter and the requirements of the elementary school teacher. Alternatively, the department of science education must assume the responsibility for offering such courses.

The content of a secondary school science methods course ideally includes all ramifications of the teaching process and atmosphere. The secondary school science teacher who is typical of the majority does his teaching in a smaller high school in a semi-isolated community. Even though he may now be teaching in a larger urban high school or rural consolidated high school, it is likely that he began his career in a smaller rural high school. Furthermore, there is no assurance that he will be assigned to teach one, and only a specific one, course throughout his entire career. In smaller schools the science teacher is not uncommonly the only person with his specialty. He is, in effect, the science department. He may teach general science, biology, and chemistry or physics each year. In larger schools, in the earlier years of his career, his assignment may include the teaching of several courses in various phases of science. In order to do an adequate job in either of these situations he must have the broadest possible knowledge of all aspects of science. It must also be as deep as time and his ability permit. He must know the many effective techniques of teaching the several areas and levels of science. He must possess information and skill in ordering, manufacturing, and maintaining a wide variety of materials and equipment—often on a severely limited budget. As new schools are built and as old schools are remodeled, his effectiveness is increased in proportion to his acquaintance with the planning and building of new and more efficient facilities. As a science expert in the school and the community he must have some familiarity with the occupational and educational opportunities in science which are available to his students. It is not unlikely that he will be requested to aid in the installation or improvement of science teaching in the neighboring elementary schools. All of the above things—and more —he must do or be. That which he needs to learn in order to carry out these manifold functions constitutes the content of a "methods" course.

Methods, themselves, are so varied and diverse that adequate sampling and experimentation by each individual in the course could well consume more time than can reasonably be allotted to the course. Yet methods, as previously stated, are inseparable from subject matter, and no secondary school science teacher is as fully

prepared in the science as is ideal. Consequently it is a further objective of the course to impart some additional knowledge in the sciences as a by-product of using subject matter to demonstrate or practice the techniques of teaching. Because of the resultant diversity of content, the staff of the secondary school science methods course should collectively possess wide interests and backgrounds and should expect to employ a form of cooperative team-teaching.

All of this is to testify that there must be much more than a few "how-to-teach" lectures in a methods course. It would be sterile to lecture on the techniques of using a microscope, a meter, or a map without providing supervised laboratory periods in which students can gain some first-hand experience. A course in the techniques of teaching science, by the same token, must provide for laboratory time in which to practice these techniques under supervision and subject to critical analysis.

While the "exact" sciences may have elements of precision, the creative leaders in the field are usually working in a realm where orderliness may well appear to be a matter of naiveté or oversimplification. At the point of advance, careful work is obligatory if one is to find a pattern or a relationship between the old and the new. In the same manner, the "good" teacher is creative. He is not content with an attitude of, "It worked last year or last century, so why go farther"?

Both the academic areas of the natural sciences and the professional areas of teaching, together with their foundational disciplines, are advancing and expanding at a steeply accelerating rate today. Be he chemist, geologist, biologist, or educationist, one must necessarily specialize or fall irrecoverably behind the rapid advance. There are few, if any, completely educated men in the ancient sense of knowing virtually all there is to be known.

Good teachers may be born, but his natural supply is strictly limited. Good science teachers can be developed, but it is a rather difficult and exacting task. Success, or the efficacy of training, is predictable statistically. There is an uncertainty principle operating here as in other fields. Research in science teaching and in the nature of the expert science teacher can increase the efficiency of the process of science teacher preparation as surely as research can show how to improve the yield of crops or ores. In this light, then, it is evident that science education is a functional department in the matter of research.

Science education, as a department, has a further function. It must provide for preparation of additional science educators. Departments of biology produce biologists as well as providing for the learning of biological facts and techniques by those who need them as general education or as foundations for other fields of endeavor. It is as ridiculous to expect an expert biologist to be an accomplished science educator without specific training as it is to expect a competent science educator to do advanced biological research without additional special preparation. Both are specialties requiring work of a different character.

In summary, a department of science education meets all the criteria which describe other established departments in the normal organization of higher education in the United States. It produces, with the cooperation and help of other departments, comparative experts in a given field of endeavor. It provides services for other departments in return. A science education department provides for the advancement of knowledge in its own realm and for the improvement of its processes through research. It maintains continuity of operation and personnel through the preparation of science educators who can carry on the work in its special field. The functions of a department of science education are as unique and important as those of any other devoted to the training of professional workers.

AN APPROACH TO TEACHING FACTS AND ATTITUDES IN THE JUNIOR HIGH SCHOOL ABOUT THE HUMAN LIFE SPAN

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. . . to be curious about that which is not my concern, while I am still in ignorance of my own self, would be ridiculous.

Socrates

Why do teachers neglect to teach facts and attitudes important to understanding the human life span? Is it because teachers do not know how to approach the teaching of the human life span, or is it because they do not have an adequate understanding of the subject? If man is to be studied, every phase of his life should be worthy of attention. The following approach to teaching facts and attitudes about the human life span should help the junior high school teacher.

DOES THE COMMUNITY THINK THE LIFE SPAN SHOULD BE TAUGHT IN THE PUBLIC SCHOOLS?

A unit of study on the human life span should not be initiated until the attitudes of the community are understood. The approach as well as the subject matter involved should be understood and approved by the community. Perhaps the community feels phases of the human life span containing sex education should be taught in the home. Most parents, however, do not object to the school's teaching facts and attitudes about the human life span if they are aware of the teacher's approach and are allowed to approve the content.

Parent-teacher groups may be good places to discuss a tentative approach to such a unit. The opportunity for parents to review the subject matter to be presented and to contribute their ideas can help in the development of a meaningful unit. Parents have insight into many problems confronting their children of which a teacher may be unaware. The parents should know the school is developing concepts and attitudes which they want their children to learn.

ONE WAY TO FIND WHAT FACTS AND ATTITUDES STUDENTS ALREADY KNOW ABOUT THE HUMAN LIFE SPAN

If a teacher is to be successful in teaching such a unit as this, he should discover what facts students know and attitudes students have about their life span. Twenty to thirty multiple choice questions are recommended for a thirty minute examination period at the junior high school level.

Three types of questions can be constructed in order to test for attitudes and facts; namely, (1) questions which test only facts, (2) questions which test only attitudes, and (3) questions which test both facts and attitudes. The following are examples of these three types of questions.

(1) Where are female germ cells formed?
   1. testes
   2. placenta
   3. ovaries
   4. embryo
   5. adult ....(1) 3

(2) Why are boys usually more active in sports than girls?
   1. because girls would rather play with dolls
   2. because it's natural
   3. because boys want to become athletes
   4. because boys are stronger
   5. because people expect boys to be more active ....(2) 5

(3) What is a sex urge?
   1. It is a form of mental and physical wickedness
   2. It is a basic drive such as thirst and hunger
   3. There is no such thing as a sex urge
   4. You don't have sex urges until you get married
   5. A sex urge is when you are in love ....(3) 2

Questions of this type will help teachers find facts and attitudes which are imbedded

within students. The results of the pre-test should be analyzed with the students.

If six life span areas are considered, a grid is suggested in order to classify the items and to obtain an even distribution of questions. The grid divides each life span period into two columns; namely, growth and development and ecology—man in relation to his environment. Construct four questions for each life span period, two on growth and development, and two on ecology. This grid will enable the teacher to obtain an even distribution of questions over the physical development and social development of each life span period.

Life Span Period	Growth and Development	Ecology
1. pre-natal	..	..
2. infancy	..	..
3. childhood	..	..
4. adolescence	..	..
5. adulthood	..	..
6. senescence	..	..

The individual questions of the pre-test should be about facts and attitudes of the human life span which junior high school students desire to know. Each teacher should ask himself, "What do the children of this age level want to know and need to know about their life spans?" There are at least three ways a teacher may find the answer to this question. First, he can survey the literature which has been written in the field; for example, Francis Bruce Strain has written several excellent books on sex education. Second, if a teacher has been keeping careful anecdotal records of each student, these records may be used to gain insight into students' problems which are related to the human life span. Third, the teacher can form a test from questions acquired directly from students. Questions obtained in these ways will lead to the construction of a meaningful test.

All five responses of the multiple choice items should function in a group. Choices which are not selected play no part in the test. One simple way to find out whether or not all choices of each item function is to tabulate the responses to each item in this grid.

TEST NUMBER

Item No.	Girls 1	Girls 2	Girls 3	Girls 4	Girls 5	Girls 6		Boys 1	Boys 2	Boys 3	Boys 4	Boys 5	Boys 6
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

If student number one gets the first item right, the space is left blank. However, if he misses item one, place the number of his choice in the square. After completing all tabulation, observe students responses in the vertical columns to see if all five items have been used. If everyone missed the question, if no person missed the question, or if all choices of the question failed to function in the group; the item should be revised before the test is used again.

Besides showing the way in which each item functions, the grid enables the teacher to compare the way the girls answer each item with the way the boys answer each item. This tabulation should show whether or not the test filled the needs of the boys as well as the needs of the girls. The following conclusions were indicated by the responses on a twenty-four item experimental test given to twenty-five boys and twenty-five girls in the seventh and eighth grade of the Elgin Public Schools, Elgin, Oregon.

1. Thirteen boys and fifteen girls did not know that girls matured faster than boys.
2. Fourteen boys and twenty girls knew where the female germ cells were formed; however, only five boys and five girls knew where the male germ cells were formed.
3. Thirteen boys and girls think nationality determines speed of growth during infancy.
4. Fourteen students thought that a sex urge was a form of mental and physical wickedness.

If the students are instructed to circle words which they cannot define in the test, the teacher can determine the vocabulary which needs to be developed. These words should be defined and used in the body of the unit. Each student will have his individual vocabulary list to study. Many of these words can be defined through class discussion since each student will not circle exactly the same words.

Teachers are hesitant to present facts and attitudes about the human life span. However, after the results are obtained from a carefully written test, the need for the instruction will be obvious. Junior high school students may have poor attitudes and an inadequate knowledge of the facts about this subject. This is evident from the conclusions indicated by the responses on the experimental test used in the Elgin Public Schools.

SUMMARY

Junior high school students need and want to know about their life span. Before a unit on the human life span is proposed, community feeling must be understood. A proposed unit of study should be presented and approved by the parent-teacher group before the unit is introduced to the students. A pre-test over facts and attitudes about the human life span can indicate what should be taught in the unit. These steps will lead to a meaningful approach to the study of the human life span in the junior high school.

A SELECT BIBLIOGRAPHY FOR A SEMINAR IN EVOLUTION

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In many of the colleges and universities of America, Evolution is taught as a seminar course. Because of the broadness of the field, important papers, that would bear discussion in such a course, appear in a variety of journals. It was felt that a bibliography of select papers would be of value to both student and instructor. Many of America's leading evolutionary biologists were invited to contribute suggestions of recent papers that they considered to be especially significant in this area. The papers listed obviously do not represent complete coverage of the field of Evolution,

but they explore their particular subjects well and should stimulate good discussion. Some of the ideas appearing herein are not necessarily accepted by all workers in the field, but there is merit in permitting the student to draw his own conclusions from the data presented.

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SCIENCE BACKGROUND OF LIBERAL ARTS GRADUATES

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THE decline in science in the high school curriculum since the turn of the century has been demonstrated by Latimer [1]. His findings, based on Annual Reports and Biennial Surveys by the U. S. Office of Education, showed a sharp increase in enrollment in biology and in general science, and a fairly constant enrollment in chemistry from 1900 to 1949, but a sharp decrease in the percentage of students enrolled in physics, zoology, physiology and botany. Physical geography, geology, and astronomy, in effect, have been dropped from the high school curriculum. The total percentage of students enrolled in science dropped from 83.9 per cent in 1900 to 54.1 per cent in 1949. These findings may account, in part, for the criticism of the American high school system of education for our failure to produce enough scientists and engineers to meet the needs of our rapidly changing technological society, and to create a more enlightened citizenry with an appreciation of scientific method and an understanding of the role of science in modern life.

The purpose of this study is to determine whether Latimer's findings are typical of a highly selected segment of the high school population who enter college and graduate with a bachelor's degree in liberal arts. A pre- and a post-war class of college graduates will be compared with respect to their high school preparation in the natural sciences. For the post-war class, the sciences taken in college will also be examined.

As a part of a broader study [2] in appraising the aims and objectives, methods, and effectiveness of two types of science courses in meeting the needs of the non-specialist at the College of the City of New York, data on science courses completed in high school were obtained for the June 1954 and the June 1941 graduates in liberal arts. To rule out the effect of other variables, women were excluded from the 1954 class since there were no women in the 1941 class; and students from a special high school with an accelerated program, permitted to take only one year of science, were excluded from the 1941 class since such students were not in the 1954 class. With the exclusion of these two groups of students, there were 212 men in the 1954 class and 222 in the 1941 class.

The data show that the 1954 class entered college with a better preparation in the natural sciences than did the 1941 class. The majority (79%) of the 1954 class completed 3, 4, or 5 years of work in the natural sciences in high school while the majority (60%) of the 1941 class completed less than 3 years. The difference between the two classes is statistically significant (at the .001 level of confidence). The median number of years of science completed was 3.09 for the 1954 class and 2.34 for the 1941 class.

The distribution of science courses completed in high school also shows significant differences between the two classes. Ninety per cent of the 1954 class compared with 27 per cent of the 1941 class completed general science. Seventy-three per cent of the 1954 class compared with 51 per cent of the 1941 class completed chemistry. Fifty-six per cent of the 1954 class compared with 33 per cent of the 1941 class completed physics. No difference was found between the two classes with respect to the proportion completing elementary biology (82 per cent for the 1941 class and 80 per cent for the 1954 class), but 44 per cent of the 1941 class compared with 2 per cent of the 1954 class completed advanced biology.

At the City College, a student in liberal arts may fulfill the science requirements for the bachelor's degree by completing two one-year courses offered by the regular departments or by completing four one-semester courses called *Science Sequence*. In the Sequence, physics is offered in the

first semester, chemistry in the second, biology in the third, and astronomy and geology in the fourth. In the 1954 class, 45 students or 22 per cent fulfilled the requirement by completing the Sequence, although in some cases the student was permitted to take three of the Sequence courses and a regular departmental course for one semester. One hundred sixty-seven students or 78 per cent completed two one-year regular departmental courses, although in some cases the student was permitted to fulfill the requirement by completing two courses in the Sequence and a year-course in one or a semester-course in two different sciences given by regular departments.

The students selecting the Sequence were exposed to all the natural sciences while those selecting regular courses were not. Of the 167 students who satisfied the degree requirement by regular departmental courses, 76 per cent completed biology, 69 per cent geology, but only 38 per cent completed chemistry and 23 per cent physics. The tendency for students to select biology and geology rather than chemistry and physics may be due, in part, to their concern with college grades. Students tended to earn higher grades in biology and geology than in chemistry or physics. Mean grades received by students in the first semester of the regular courses were computed in the following manner; an A grade was given a numerical weight of 4, a B grade was given a numerical weight of 3, a C, a numerical weight of 2, a D a numerical weight of 1; Ab (Absent from final examination), F (Failure), G (Dropped with a failure for unsatisfactory scholarship), J (Dropped without penalty) was given a numerical weight of zero. The mean grade and standard deviation were 1.44 and 1.06, respectively, for physics; 1.94 and 1.13 for chemistry; 2.17 and .99 for biology; 2.34 and .94 for geology. The mean grade was significantly lower in physics than in chemistry, biology or geology, and significantly lower in chemistry than in geology.

A more detailed analysis shows even more clearly the failure of students to round out in college their high school deficiencies. Of those taking regular courses, 8 per cent did not have a course in biology in high school or in college, 14 per cent had no chemistry, 34 per cent had no physics, and 9 per cent had no chemistry or physics in high school or in college. Of 60 students who had completed four years of high school science including general science, biology, chemistry and physics, 30 per cent did not take geology. These students constituted 11 per cent of the group.

SUMMARY AND CONCLUSIONS

This study of the science background of post-war liberal arts graduates suggests, in contrast to the trend demonstrated for unselected high school students by Latimer, that students enter college with a better preparation in science, especially in the physical sciences, than did those in the pre-war period. Since the data also suggest that students fail to round out their science preparation in college, but rather tend to choose the same courses taken in high school, colleges might well consider requiring students to take sciences which they did not have in high school, or a sequence course covering work in all the natural sciences. For liberal arts candidates who enter college as well prepared in the sciences as many in this study, it may be advisable to make science requirements more flexible with a provision that the student may substitute courses in other departments which may be of special value to him, for those courses in which he has had adequate high school preparation. He may, for example, take courses in mathematics, philosophy of science, history of science; or, in colleges requiring more than one science, advanced study in only one field.

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